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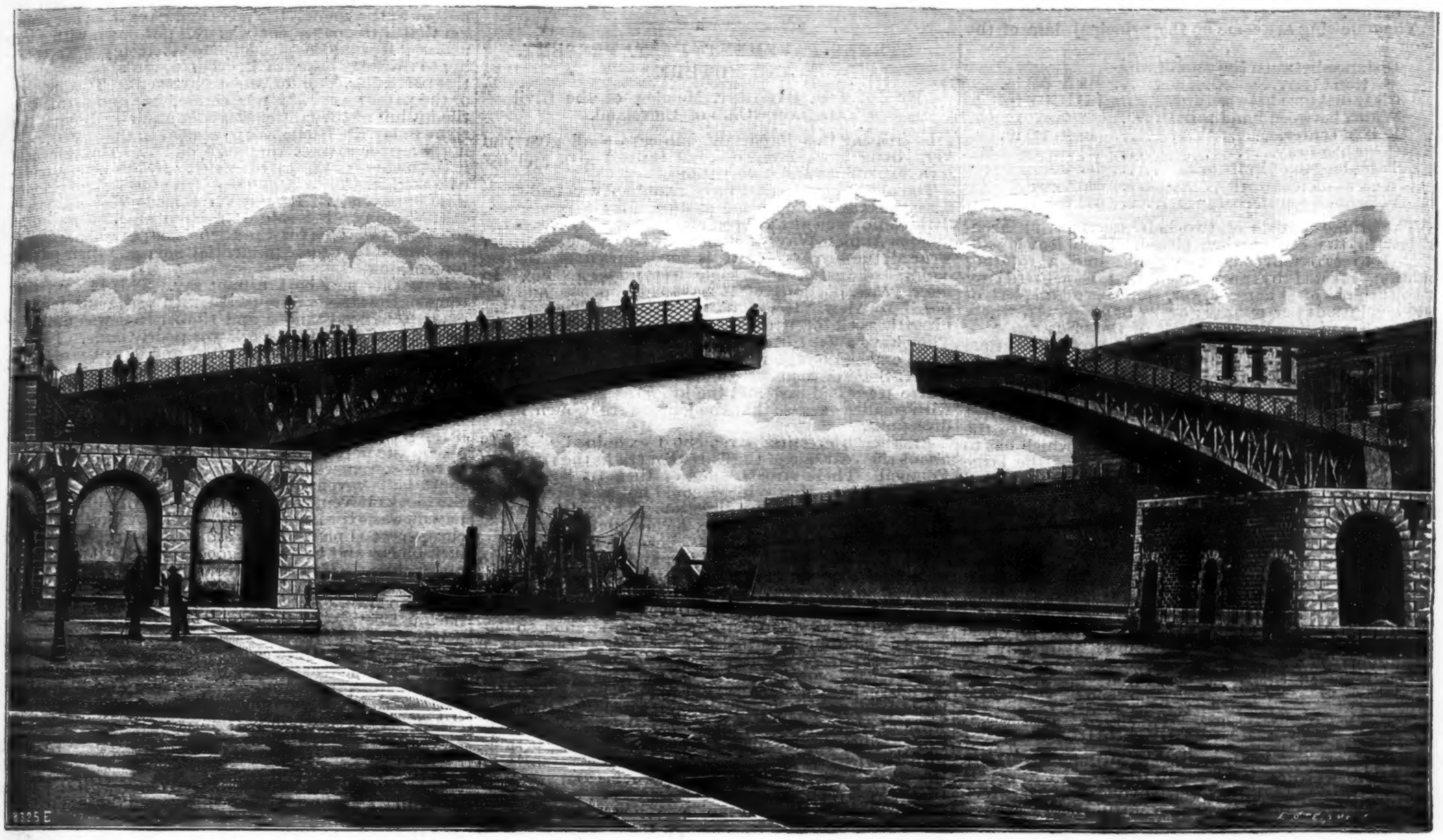

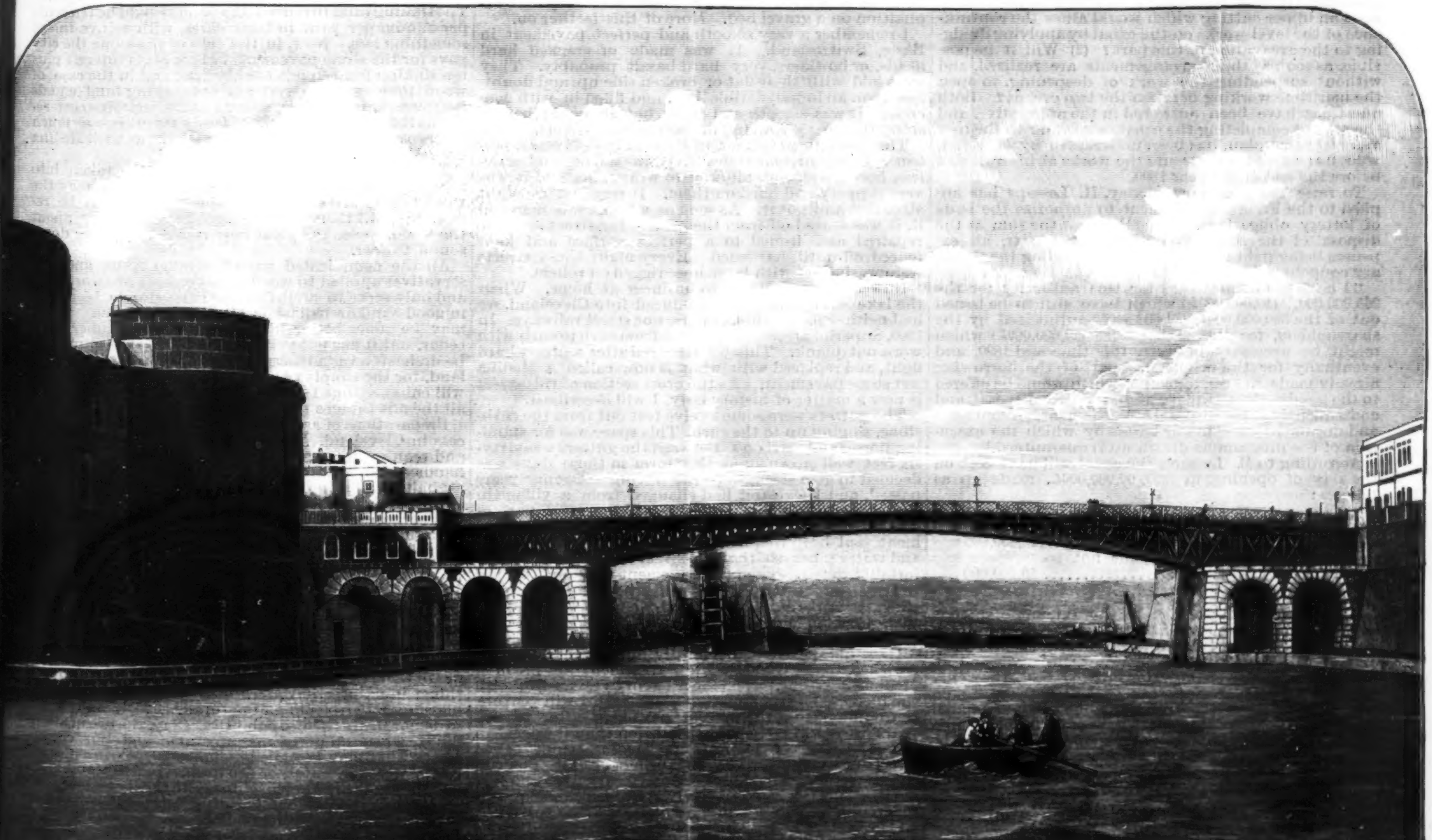

LIFTING BRIDGE AT TARANTE, ITALY.

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This bridge crosses the canal that forms a communication between the so-called great and little seas of Taranto, and joins the new town with the old one. This fine work, which was carried out by the Impresa Industriale Italiana di Construzioni Metalliche, directed by Mr. A. Cottrau, was opened for traffic with much ceremony on May 22 last, and is undoubtedly the finest example of its class in Italy. The original scheme is due to Vice-Admiral Acton, who, with the intention of putting it into execution during his tenure of office as minister of marine, put out the work to competition among the various Italian constructors. A large number of firms responded to this proposal, and the project that was accepted was the one submitted by the Impresa Cottrau of Naples, on account partly of the very great economy of the design, and partly because of the elegance it displayed and the simplicity of the hydraulic mechanism employed for opening and closing the bridge.

The following are some of the principal data of the work:

Distance between the axes of rotation	219 ft. 9·8 in.
Clear distance between abutments	188 ft. 3·9 in.
Width between hand rails	22 ft.
Rise in center	12 ft. 1·6 in.
Clear headway	41 ft.
Total length of ironwork	292 ft.
Weight of ironwork	526 tons.
Weight of counterbalance	582 tons.

The bridge consists of two half arcs meeting accurately in the center when closed. Each leaf is subjected to two movements, a rising and a rotating motion, effected by mechanism that is actuated by two turbines of 14 horse power, working at a speed of 240 revolutions per minute; or by hand power, where 36 men are required at each half of the bridge to work the capstans provided for the purpose. The time required for opening or closing the bridge by hand is 17 minutes; with the turbines the complete operation is effected in 5 minutes. The two turbines are driven from a large reservoir holding about 20,000 cubic feet of water, and placed at a height of 62 ft. above the mean sea level. The rotating movement which has to be given to each arm to allow passage for the large ironclads is obtained from two large wheels mounted on Vignoles rails and placed at the end of the abutment, where they are controlled by a system of gearing worked by the turbines. The rising and falling movements are obtained by four nuts worked from an endless screw and by gearing driven from the turbines. Before the bridge was opened for traffic it was tested with a uniformly distributed load of 380 tons, which was kept on the platform for twenty-four hours; the maximum deflection that took place under this load was 3·35 in., or exactly half the amount allowed in the conditions of the government scheme. On the load being removed this deflection wholly disappeared.—*Engineering.*

THE PANAMA CANAL.

M. Ferdinand De Lesseps has abandoned his original project of a level canal from ocean to ocean, and has announced that the summit section, which was to have passed through a cutting 350 ft. deep, is now to be at a high level, and to be reached with locks. He has demanded of the Consultative Commission: (1) Is it possible to construct in the central mass an upper cutting which would allow the continuance of the level works on the canal by applying dredging to the excavation of this part? (2) Will it be possible, as soon as these arrangements are realized, and without suspending the work of deepening, to open the maritime working between the two oceans? Both questions have been answered in the affirmative, and the task of completing the canal, according to the new and restricted plan, has been undertaken by M. Eiffel, who has agreed to execute the works at his own risk before the end of the year 1890.

To raise the necessary money, M. Lesseps has applied to the French government to authorize the issue of lottery obligations. He states that the sum at the disposal of the company on January 1 next, all expenses being paid up to that date, including the January coupons, will amount to 4,400,000*l.* He adds:

"I have the honor to ask for this authority for the 265,000,000*f.* (10,600,000*l.*) which have still to be issued out of the 600,000,000*f.* (24,000,000*l.*) authorized by the shareholders, for the 300,000,000*f.* (12,000,000*l.*) which might be necessary between this time and 1890, and eventually for the whole or a part of the borrowing already made, the conversion of which would be offered to the bondholders. I place at your entire disposal, and consequently at the disposal of Parliament, all contracts and documents now in our hands by which the execution of the programme drawn up is guaranteed."

According to M. Lesseps, the canal will have cost on the day of opening, in 1890, 60,000,000*l.*, made up as follows:

	£
Share capital	12,000,000
Obligations (already issued)	25,400,000
" (authorized, but not issued)	10,000,000
Loans not yet authorized	12,000,000

This estimate must refer to the amount of money actually received, and not to the indebtedness of the company, for the last two sets of obligations have been put on the market at 55 per cent. discount, and although nominally of the value of 20,000,000*l.*, they only realized 9,000,000*l.*, supposing that they were taken up. The revenue of the canal, when made, is estimated at 4,500,000*l.*, derived from a tax of 15 fr. per ton on seven and a half million tons of traffic. This is to be distributed as follows:

	£
Six per cent. on 48,000,000*l.* loan	2,880,000
Administration	200,000
Repairs	240,000
Interest on share capital (5 per cent.)	600,000
Incidentals	160,000
	4,080,000
Balance for dividend	420,000
Total income	4,500,000

In the year ending January, 1887, nearly 12,000,000 cubic meters of soil were excavated, and the rate of working has probably somewhat increased since. There now remains, with the altered arrangements, 40,000,000 meters to be removed, so that M. Eiffel has a busy time before him to get all this dug out during the next eighteen months, besides doing all the other work which lies before him. What is he going to do about the River Chagres, the controlling works for which are estimated in a report just published by Senor Armero, the agent at Washington of the Colombian or Panama government, to cost 19 millions sterling by themselves? In many places the canal follows the bed of this river, which has been known to rise 44 ft. in a few hours. It appears, however, that the company has determined to close its eyes to all difficulties and to run all risks in order to make a show of success to parade before the shareholders, and to save its concession, which will lapse in 1892, if the canal is not working.—*Engineering.*

STREET PAVEMENT—PAST, PRESENT, AND FUTURE.*

By John H. Sargent, Member of the Civil Engineers' Club of Cleveland.

In treating this important subject I shall give you very little of its literature, but instead give you my own experience and observations.

The oldest pavement I have examined was laid some 2,200 years ago, and, so far as durability is concerned, little improvement has been made since. This was the famous Appian Way, at Rome. It has not been under wear all these years, for it is now buried by the accumulated dust of ages, some feet under ground. In later years, portions of it have been opened and exposed to view. It was paved with hard trap or porphyritic rock of irregular or accidental dimensions. They have a flat surface and looked like, and may have been, cracked bowlders from the bed of the classical Tiber. Some of them were more than a foot in diameter. These were laid first and the interstices were filled in with smaller ones, so that the joints were broken in all directions.

Another interesting pavement I examined was laid about the year one of the Christian era in the streets of Pompeii. These streets, some of them at least, were very narrow, so that vehicles could not pass each other, so they had to go in one direction. Their cross walks were stepping stones some six inches high, so that the wheels and animals had to pass between them. Before the ashes of Vesuvius came down and filled them up to the second story of the houses, ruts had been worn into them some four inches deep and from four to six inches wide. I was able to measure the gauge of their vehicles, and found it to be our standard gauge, so *that* came down from ante-Christian times, or, perhaps, from the eternal fitness of things.

The macadamized roads across the Alps are great, enduring monuments of the skill and enterprise of Napoleon Bonaparte. I say enduring, but a macadamized road without constant care and attention would soon go to ruin. These Alpine roads have this care, and besides, little children six or eight years old are constantly on the roads with their baskets and brooms and sweep up the horse droppings and all else that will tend to keep up the overtaxed soil. I may as well say just here that a macadamized road is, perhaps, the most suitable of any for a country road heretofore tried, but there is hope in a water-tight floor of indurated clay and asphaltum on a gravel bed. More of this farther on.

I remember a very smooth and perfect pavement in Basle, Switzerland. It was made of cracked hard heads, or bowlders, very hard basalt probably. They were laid with their flat or broken side up, and doubtless upon an indestructible bed, and filled in with concrete. It was smooth and clean, but it would hardly stand the heavy teaming of our business streets.

The asphalt pavement of Paris in 1867–68 was a perfect roadway in some respects. It was smooth and noiseless, horses were not allowed to wear calks, and it was very slippery and hard on them. It required constant attention and got it. As soon as a break was made in it, it was fenced off from the rest of the street and was repaired and ironed to a perfect surface and kept fenced off until hardened. Every night these streets were washed off with large hose rigged on rollers.

Now I will come down to business at home. When the lake water was first introduced into Cleveland, we had neither pavements, sewers, nor street railways. In 1860, Superior street was covered from curb to curb with worn-out plank. This we removed after a pretty hard fight, and replaced with what is now called a Medina wet stone pavement. As the cross section of this street is now a matter of history only, I will describe it.

The gutters were some twelve feet out from the curbstone, sloping up to the curb. This space was for standing horses and carriages. Between the gutters was sixty-six feet well crowned, as this form in those days was deemed to give strength to the paving. Twenty years passed, and Cleveland had changed from a village in character to a pretentious city. All the level part of the street was occupied by street railways, the pavement had been frequently disturbed to lay sewers, gas and water pipes, so that the street had become uncomfortably rough. Then the pavement was renewed and the roadway reformed to suit the altered circumstances. A percentage of the stone was fit to relay in the least exposed part of the street. These were used and the balance was laid with new material.

It would, perhaps, be hardly fair, with this experience, to say that with fair treatment the life of a Medina wet stone pavement is twenty years. But with the increased duty upon Superior street, I will venture the opinion that the present pavement after twenty years' wear will be in worse condition than it was when last renewed. Other of our Medina stone paved streets have been renewed and others need it. Some of the streets have stood, I believe, twenty-five years or more. This is a comparatively durable pavement, but it is rough and noisy and hard on horses and carriages. In the matter of roughness the Medina dressed stone pavement while new has the advantage of being less rough. The wet stone becomes smoother by age, while the dry becomes rougher, especially where exposed continually to the action of horses' calks, as in the street railway tracks. I do not think the dry stone has any advantage over the wet in point of durability, and is much more expensive.

About the time of the introduction of Medina stone into Cleveland, and perhaps before, some streets under the hill, and I believe one half of Superior hill, were paved with limestone of like dimensions with the Medina. These proved a failure; they would not stand the weather. If, after being laid three or four years, they were taken out, they would fall to pieces. One side of Superior street hill was paved with Independence sandstone, from a single layer of flagging near the surface. Many of them did good service, but they were irregular in thickness and hardness and in limited quantity. These last and the limestone, I believe, have all disappeared.

About the time of the close of the war the Nicholson pavement fever broke out. I was one of a committee sent by the council to Chicago to investigate. We took up a block in a street that had been paved some four or five years, observed its condition and wear, and reported to the council the facts and gave it as our opinion that if the pavement was well put down with good material it would last from ten to fourteen years, according to the duty asked of it. There was a patent upon this particular form of wood pavement. The holders of the patent went for our council hot and hard, and the upshot of the matter was that the city bought the right to lay the Nicholson pavement in the streets, paying therefor several thousand dollars. How much of it the owners of the patent got has always been a mooted question. Then began the strife for this particular kind of pavement. Its cost was considerably more than Medina stone. It is said that sharp practice was used to secure petitions for the Nicholson pavement, and it was hinted that some influential men got their paving for nothing.

How this may be I cannot say. This I know, that some of the streets were paved with very poor lumber, made from dead timber and timber that was unfit for anything else, and the work was poorly done. The result was that the blocks rotted and disappeared in a very few years, while others lasted their allotted time of twelve years. A notable case is Franklin street, between Pearl and the Circle. This was paved in the fall of 1869, and the south half of this section has had very little repairs and is a good roadway yet. For some reason the north half has not done as well, and should have been renewed two years ago. The service of the south half—seventeen years—is something remarkable; the blocks have not rotted, simply worn out. But the patent was expensive and not good. A far better and cheaper wood pavement is cedar poles cut into eight inch blocks and bedded in good gravel without boards under them. Madison street, Toledo, was paved in this manner with red cedar from Tennessee, and has now stood quite a number of years without repairs and has, as I believe, in no wise failed.

Upon streets with business enough to wear them out before they rot, white cedar would do as well, say for ten or twelve years, while the cost is not one-third of Medina stone pavement, and carriages and horses and their shoes will suffer much less on them than on the stone. These white cedar blocks are quite popular in Detroit and other Michigan towns. This pavement is so simple in construction that its renewal is made with little interruption to travel. As a question of economy let us compare the Medina dressed block with the white cedar block as a basis. We will assume the stone block to cost $3 per square yard, and to last thirty years, and the cedar block to cost $1 and last ten years, and that the city issue four per cent. bonds to do the work. The sinking fund to redeem the bonds would be ten cents per annum per yard in both cases, with reinvestment something less. Now, in the case of the stone the city pays for the stone pavement twelve cents interest plus ten sinking fund equals twenty-two, and in the case of wood four cents interest and ten sinking fund equals fourteen cents. Hence, so long as the relative cost remains the same, it will cost scarcely two-thirds as much to keep a street paved with cedar blocks as with Medina dressed stone.

There is a sanitary consideration to be taken into account as between wood and stone. As soon as the wood begins to decay it fails, and will have to be renewed; until then there is nothing unhealthy about the wood, hence the great importance in putting down sound timber.

All the complicated patent arrangements and preservatives applied to wood in pavements are worthless, and only serve to swell the cost; the simple block set in good sand or ballast is all that is wanted. There may be some better kind of pavement timber than cedar, but it has not yet been found. I do not wish to be understood as advocating wood pavements for Cleveland, for the supply of cedar will give out, and its cost will enhance, but I wish to give all kinds of pavement all the advantages they can justly claim.

Preparations of asphaltum have not so far been a success in Cleveland. Their composition is too uncertain and requires too much attention to be trusted in the hands of an ordinary board of improvements. The asphaltum as a top dressing combined with sand, and as an article for filling in the joints of stone and brick, and perhaps wood, is no doubt valuable. For sidewalks an artificial stone or concrete makes a better and more enduring material than our sawed and split sandstone, but it will have a hard fight to compete with it in cost. Broken stone, slag and cinders for city streets are little better than the natural soil.

In conclusion, I wish now to treat of a material for pavement with which we in Cleveland have had little experience. It is so abundant, so accessible, and so cheap withal, that people discard it as but the dust beneath their feet. So it is with many of the most common things in nature; they often turn out to be our greatest blessings. Petroleum and natural gas took many years to demonstrate their capabilities. Clay, the ore of aluminum, when properly manufactured and burned, becomes what may be called an igneous rock, unaffected by the weather, water, or fire itself. It will stand more pressure in the testing machine than the best of granite. It is homogeneous and slightly elastic, it will neither act upon the horses' shoes nor be acted upon by them. I speak now of brick made of fire clay. They should be burned hard enough to partially vitrify the moulding sand on their surface. In this condition you cannot sharpen your ax upon them, nor wear away their surface by attrition. The tenacity and wearing quality of an ordinary brick is remarkable. The mason, when he has to shape a brick, will not attack a hard burned

* Read March 22, 1887.

one. If he does, watch him, and see how little effect he has upon it with his sharp steel trowel. Look at our tall brick buildings, and see what pressure ordinary brick have to sustain. The walls of my own homestead have stood the buffetings of sixty alternating seasons of frost and heat and storm unimpaired. The bricks of the old Roman ruins, shattered by earthquakes, fire and war, stand out sharp and jagged; these bricks are but one and a half inches thick, but they, the individual bricks, are now as sound and solid as they were two thousand years ago.

It is thought that the fire clays of our coal measures will produce a better brick for pavements than our common red clays.

I am inclined to think this is so, but the common brick have been used in Charleston, West Virginia, and Bloomington and other towns in Illinois for a dozen years. Some taken up after ten years' wear had been worn down less than a quarter of an inch. Experience only can determine the best clay and best treatment. Last fall a small section of fire brick was put down in the street railway track at the intersection of Detroit and Pearl streets, and another at the intersection of Ontario and Michigan. I would invite the members of the club to examine them. I can see no perceptible wear or deterioration. Aside from the question of durability and economy, they make a very smooth, quiet, and dustless street. There are certain patent schemes for brick pavement, but they are all "no good," and come under the same category with patents on wood pavements. A perfectly formed and consolidated roadbed made by rolling or pounding and covered by a single course of bricks laid edgewise, with the joints filled with hot asphaltum and sharp sand, makes a perfect, continuous floor, on a foundation that cannot escape.

The only pavement that can now come into competition with this in Cleveland is the Medina sandstone pavement. We will now examine this material. The Medina sandstone is a compact and hard sedimentary rock. All sedimentary rocks are, however, laminated, and have a cleavage parallel to the beds, and they are laid in the pavement in a way favorable for the horse calks to act upon them. As a result, observe the stone in the railway tracks in Superior street and on the Viaduct, and you will see the dressed stones converted into bowlders as rough as any well laid bowlder pavement. There is another cause for the wearing away of a sandstone, however hard it may be. It is composed of silicious particles that will "bite" iron and steel. The same force that acts upon the shoe reacts upon the stone. The grindstone cuts away the steel tool, but the tools ultimately wear out the grindstone. Clay or brick has no grit that will bite steel, and on that account will not be reacted upon by the steel. So they cannot destroy each other. From my observations I believe a brick pavement can be made to outlast in good condition a Medina stone pavement, and will cost much less. How much less we shall soon see. If it should be found on investigation that the fire clays are the most suitable for pavement, they exist in great abundance within easy access to Cleveland by canal and rail.

The chemical constituents of the clay should be taken into account. It is clay that gives the hydraulic quality to the water limes. The physical qualities of fire clay may be divided into the hard and the soft plastic, but not differing greatly in their chemical constituents. Singularly enough, the plastic has less combined water and alumina and more silica than the hard. On this account I should expect the hard to make the better brick for paving. Lime, uncombined at least, would probably be deleterious. Here is a specimen of the hard variety from New Cumberland, West Virginia, on the Ohio River. There it is burned with natural gas in down-draught kilns or ovens. They may be burned in the same kind of oven with slack coal to any degree of hardness required, as they are in Tuscarawas County. One happy circumstance is that the bricks too soft for pavements are better for furnace linings than the harder ones, and worth quite as much.

Individual residents of Franklin avenue, being in West Virginia, observed some of these brick pavements, some that had been down three years, some twelve, and were struck with their smoothness and good condition. A public meeting was called and a committee was appointed to gather information. They went to Wheeling and examined the pavement, and to New Cumberland to examine the material and its manufacture. The committee was very favorably impressed, and reported advising the use of fire brick for Franklin avenue. Here are several letters received by the committee, which the club would perhaps be glad to hear read. If so, I will ask Mr. Holloway to read them.

The board of improvements has advertised for proposals for both brick and Medina dressed stone pavement. When these bids are opened we shall be able to see the relative cost. If the specification prepared for the brick pavement by the board have no unnecessarily expensive requirements, I shall expect the brick pavement to cost little, if any, more than one half the stone. At the same cost, and I have a long front to pave, I should much prefer the brick. The cost of a foundation for the one is practically the same as for the other. The brick will have a more perfect bearing than the stone, for the bricks have a full bearing bed all alike, and are of the same depth, while the stone are of unequal depths, and the lower end more or less wedge shaped. The bricks will fit far closer together, and hence will require much less asphaltum filling, and having a smoother surface, will shed off the water more perfectly.*

DISCUSSION.

At the close of his paper, Mr. Sargent announced that he had with him a number of letters on the subject of street pavements, and they would be read by Mr. J. F. Holloway.

Mr. Holloway first stated that these letters were replies to inquiries made with the view of going to the root of the matter, and were written by persons who had no interest in pressing the claims of any pavement.

A. H. Bell, city engineer of Bloomington, Ill., stated that the citizens were highly pleased with the brick pavements. The bricks are ordinary clay brick burned very hard—almost vitrified. Where there is no grading or foundation to prepare, the pavement costs $1.15 per square yard laid down.

P. Whitmer, of the People's Bank, Bloomington, stated that since Bloomington had tried brick pavements, Galesburg, Jacksonville, Champaign, and other cities had adopted brick, and all were pleased with it. In Bloomington, an inch of sand was first put down, then a course of brick, laid flat, on which was placed a thin layer of sand, then a course on edge as close as convenient, say a quarter of an inch apart. On top of that enough sand to fill the interstices, and it is done.

The "Riverside Steel Co.," of Wheeling, W. Va., stated that the citizens were so much pleased with the brick pavements that they were being used to the exclusion of every other kind. Those laid three years ago do not show any appreciable wear, and they do not become smooth and slippery in winter. They are almost noiseless, and are easily swept and kept clean. The drainage is quick and complete. The pavements can be built at a cost of $1.60 per square yard, which includes all material and labor and preparing a bed to receive the substratum of gravel or sand. The blocks are 9" × 3" × 5", and weigh 9 lb. 10 oz. each.

J. P. Hale, of Charleston, W. Va., stated that the clay used for paving brick was simply a good quality of common building brick clay, tough, stiff, and tenacious. Such clay could be found in the vicinity of almost any city in the United States. The writer believed that brick would eventually supersede every other material for street paving. In his opinion it is not only the cheapest, but the best, material that can be used.

Prof. I. O. Baker, of the School of Civil Engineering, Champaign, Ill., stated that the cost of brick pavement varied there from $1.60 to $1.87 per square yard, according to the freight on brick or sand. It had been tried three years, and no sign of wear could be discovered.

W. McD. Hiller, of Steubenville, O., said that a test square of vitrified fire brick set on edge was put down three years ago, and had not cost a cent for repairs since. Parts of several streets are now being paved. Some blocks cost as little as 85 cents per square yard, including everything. Others cost more because the excavated materials have to be hauled further, and because there is not a natural foundation of gravel; but all cost under $1. The hard-burned red brick stands five tons pressure; the new Cumberland fire brick, eighty tons pressure. It is smooth, but never slippery. Horses never slip on it in winter.

The prospectus of the "Hale Pavement Company," of Staunton, Va., containing a large number of testimonials from various cities, was referred to by Mr. Holloway. This company claim that their pavement is durable and serviceable, economical, clean, healthful, and comfortable and noiseless. The material for the pavement is, first, sand, then boards dipped in hot coal tar, then hard-burned brick.

Mr. Holloway: Last fall, in Allegheny, I saw a street paved with fire brick. The street has residences on one side, and on the opposite side there are terraces sloping down to the depot. The first thing that struck me was that they were laying courses of brick flat ways. I asked a gentleman why they did not set them on edge. He replied that they were trying an experiment. I said that I supposed that they would have put lower courses of good red brick. He said that there was not much difference in the cost. A gentleman who was passing stopped and said that the way in which this was being laid down would not answer. The agreement was that they should have just such a street as the block above. From what was said afterward, I gathered that the people were very much pleased with the paving of the block mentioned, which had been laid over a year. I walked then to the block above. It was very clean. I did not see a broken brick or a soft brick in the whole street. While I was there a great many teams passed. It was a little down grade, but they never halted, showing that the horses had confidence in it. I listened for the sound of the wheels. I could hear the click of the horses' feet on the pavement, but there was no rumble of wheels. It was almost noiseless.

Mr. H. M. Claflen: As to Medina stone, I could read a number of letters giving favorable criticisms, but I do not wish to put myself in the light of a patent medicine vender. The people in Bloomington have no stone. The brick pavement is a great improvement upon the mud. So with the other little towns. What do the people in Harrisburg know about pavements? Of all the slow-growing places in the world, Harrisburg will take the palm. When you go to cities that are cities, do you find them adopting fire brick, or any other brick? I saw in San Francisco one street paved with brick. It is the only street, so far as I can learn, ever paved there with brick. Brick was put down in Chicago and has been taken up. In St. Louis they went to great expense and tested all sorts of pavement. Did they adopt fire brick? No; they adopted granite. The city of Toledo was about to pave one of its streets. A fire brick man tried to induce the people to adopt his pavement. I went up there, and last night the contract was awarded me. The Topeka people have tested all kinds, and have declared against fire brick, and have adopted stone and asphalt. I am going to lay it down as my creed that an artificial pavement, if any other can be had, is a very foolish device. When the material is subject to the action of the weather, horses' feet and so forth, the artificial pavement may not be enduring. The only material practicable for pavement is stone. When you lay it well, you get the best results. Mr. Sargent compared wood with Medina stone. He placed the lasting qualities of Medina stone at thirty years and those of wood at ten years. If you look at any street paved with wood that has been down for ten years, you will see that it has been down at least three years too long. I can show Mr. Sargent a street where the stone was laid down fifty years ago. I want to ask, as an engineering problem, how long a street laid with block pavement will last? River street was laid thirty years ago. A year ago last summer we took up a part and relaid it. If any one will examine it, he will see that it is one of the prettiest pieces of pavement to be found, though it was laid in an unmechanical manner. You can see Medina stone in your own city. In Buffalo you can see 100 miles of streets paved with it. It is as lasting as granite. It is not as noisy nor as slippery. You can saw and polish granite, but you cannot saw or polish Medina stone. I examined some granite laid on Fifth avenue. It is laid much like Euclid avenue block stone pavement, but it does not begin to compare with the block stone pavement laid in Cleveland.—*Journ. A. E. S.*

WILLIS' SPEEDOMETER.

THIS instrument, invented by Mr. R. Willis, is intended for indicating the speed of screw or paddle shafts of steamships, the speed at which locomotive engines are running, the revolutions of stationary en-

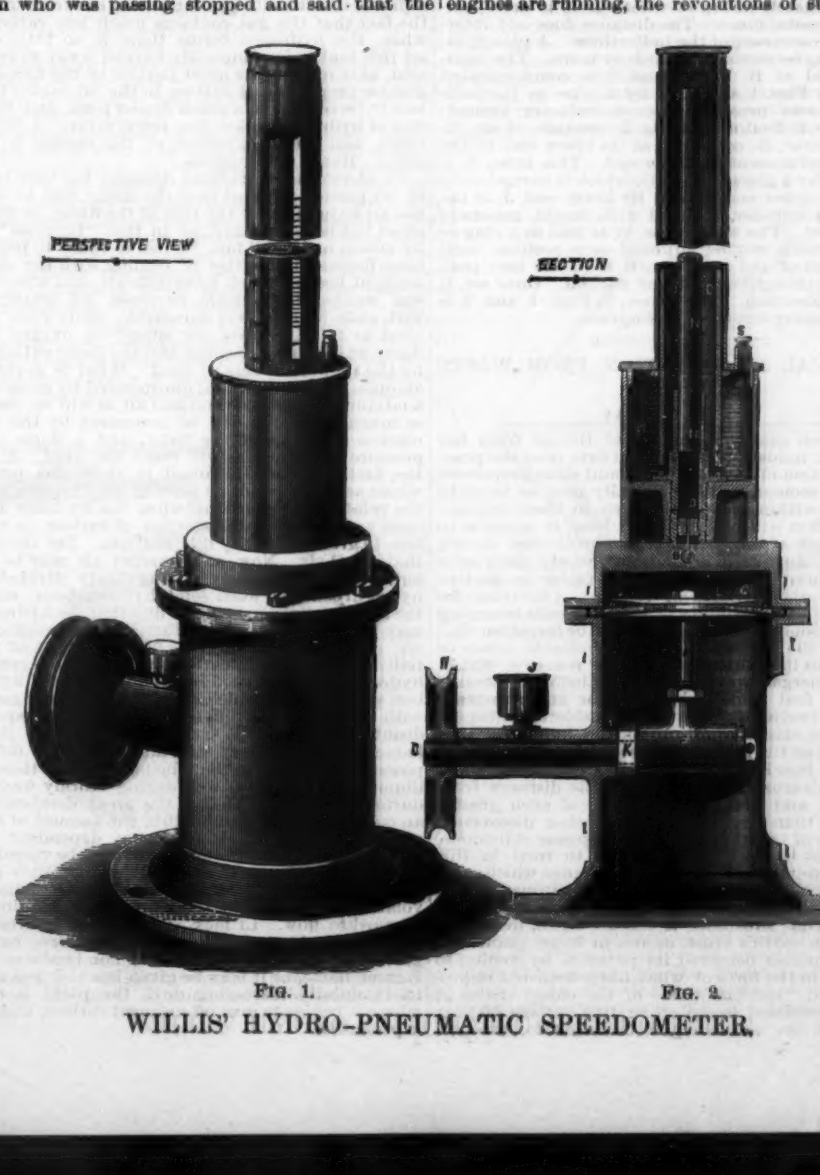


FIG. 1. FIG. 2.

WILLIS' HYDRO-PNEUMATIC SPEEDOMETER.

* Since this paper was read, the dressed Medina stone pavement in the street railroad tracks on the Superior street viaduct, laid in 1879, has been taken up and relaid. Nearly all of them had to be redressed and a notable percentage of them replaced by new stone, while the brick pavement laid in the same tracks at the Detroit street crossing last fall show little or no signs of deterioration.—J. H. S.

gines and of high speed machinery. A special feature is that the indicator may be placed apart from and irrespective of the position of the shaft or wheel to be speeded; the motive part—a piston—and the indicator being connected simply by an ordinary iron or brass tube, carried in any convenient manner, and may be even 100 yards or more apart. Thus, as is very desirable on board ship, one motor fixed near the shaft may actuate two or more indicators placed in engine room, ship's cabin, or other desirable positions.

For ventilating fans, dynamos, and in many other cases, it is often very desirable to have the indicator fixed apart from the motor, and also to have a second indicator placed where the manager or foreman can conveniently see it. The parts of the instrument likely to require renewal are very readily replaced, without having recourse to the maker. The glass tubes of the indicator are ordinary boiler tubes, which are everyday articles of commerce. The instrument has been thoroughly tested, and is, we are informed, uninfluenced by variation of temperature, and cannot get out of adjustment.

Referring to the engravings—Figs. 1 and 2—H is a pulley, to be driven by the shaft which it is desired to speed; G, a spindle which has an eccentric end, F, carrying the piston rod, E, up and down about ¼ in.; J, Stauffer lubricator which oils shaft, G, and by a small hole in K it also lubricates eccentric, F—the shaft and eccentric are the only parts requiring lubrication; I I, cast iron case; A A, India rubber diaphragm fixed in cylinder, I I, and held in center by the piston, L L—this diaphragm is carried up and down by the eccentric and is kept from bagging by the piston cheeks (brass), L L. Fig. 3 is an enlarged

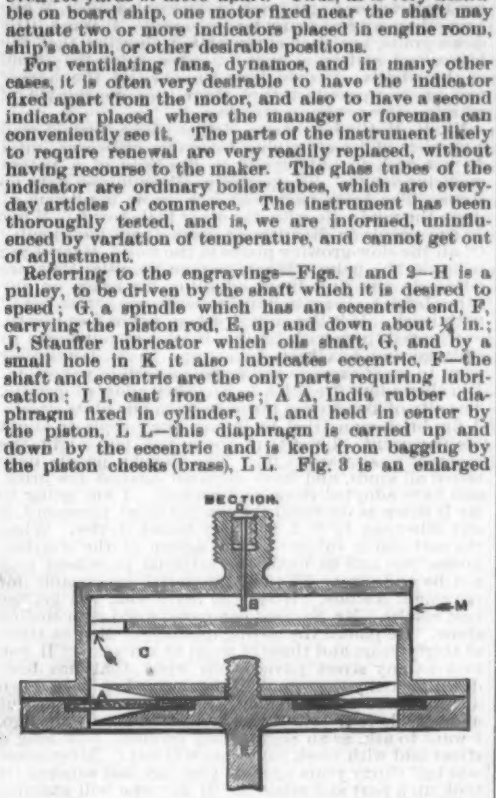


FIG. 3.—SECTION OF SPEEDOMETER, PISTON, COVER, AND PORTS.

section of the piston, the cover, and ports. C is an air hole through which the air is forced out and drawn through the air passage to the outer air at M; B is a small tube which crosses the air tube, extending only to the center of the passage. As the air is forced in and out the passage, M, it forms by induced action a partial vacuum in this small tube, B, the amount of vacuum depending upon the speed of the spindle. This partial vacuum is made the means of obtaining constant speed indications.

The indicator tube holder is connected to the top of the cover as shown at D, in section, Fig. 2, and thus to the motor, or piston portion, but it may be connected either immediately above or wherever it is more convenient, by metal pipes. The distance does not interfere with the accuracy of the indications. A pipe ⅜ in. diameter may be carried 100 yards or more. The vacuum produced at B, Figs. 2 and 3, is communicated direct, as in Figs. 1 and 2, or by a pipe to the indicator, and acts precisely like an ordinary vacuum gauge. The indicator—see Fig. 2—consists of an interior glass tube, N, connected at its lower end to the nozzle, D, and open at its upper end. This tube, N, is surrounded by a glass tube, O O, which is hermetically sealed at its upper end, T, and its lower end, J, is immersed in a cylinder, P, filled with liquid, generally colored water. The small tube, B, is held in a plug or nipple, D, which can be adjusted as to position until the lower end of the fine tube, B, is in the best position for obtaining the induced suction. Once set, it needs no alteration. The screw, S, Figs. 1 and 2, is also an adjusting screw.—*The Engineer.*

ECONOMICAL ILLUMINATION FROM WASTE OILS.

By J. B. HANNAY.

IT has been said that the fall of Britain from her place among industrial nations will date from the practical exhaustion of her coal fields, and some prominent writers and economists have actually gone so far as to calculate to within a few years when, in their opinion, this exhaustion will be complete. Now, it appears to me somewhat strange that thoughtful men should have made any such prediction. Surely their eyes must have been closed to that huge factor in modern civilization—the advance of science. Admitting for the moment the possibility of our coal beds becoming exhausted sooner or later, it must not be forgotten that there is in the British mind an illimitable power of invention, an inexhaustible wealth of resource, which, when the emergency arises—and long before it becomes acute—will find some substitute for any substance which may previously have been considered indispensable to the existence of any of the industries that maintain us as the first of commercial countries. When we consider how ignorant we really are of the resources of the earth's crust at any considerable distance from the surface, and that new coal beds of even greater dimensions than the old ones are being discovered, calculations of the kind referred to appear ridiculous. But it is not of coal that I intend to treat in this paper. I propose to deal with a substance which, as a source of light and fuel, I believe will ultimately render coal of merely secondary importance in our manufactures. That substance is the oil which, in certain parts of the earth's crust, occurs in large quantities, and has in places betrayed its presence by coming to the surface in the form of what have been not improperly termed "springs." One of the oldest trades in the world consisted in collecting this surface oil near the Caspian Sea, and selling it in Persia for the production of light and heat. And it is of some modern developments of this ancient trade that I would speak to-night. I need not here tell the members of this society of the inexhaustible stores of this oil at Baku, on the Caspian. Neither need I allude to the indications, amounting recently to proof, that similar stores exist in nearly every division of the earth's crust, not excepting even New Zealand; nor that railways, steamers, and stationary engines are being run by oil fuel in Russia, India, Egypt, and America, and will soon be running here, as this information has already been given in a masterly manner by Mr. Chas. Marvin, whose patriotic labors merit national recognition.

The proofs are all there that, locked up in the earth's crust, and at no great distance beneath the surface, are enormous reservoirs of oil, the most economical and convenient form of fuel in existence. At present practical men are busy arranging to make this store available for our use in the manifold operations which engineering has established during the century. Pending the opening of these stores, there are at present ready for use large quantities of waste oil, obtained as a by-product from some of our great manufacturing industries, the disposal of which was, until recently, a puzzle to chemists and engineers.

In one industry alone—namely, iron smelting—there could be manufactured enormous quantities of crude oil, and even the few furnaces already fitted with condensing apparatus are sending large quantities of oil into commerce at a very remunerative price. I believe it will not be long before every blast furnace will be fitted with its condenser, and thus add to the fertility of the country by securing the vast quantities of ammonia at present lost, and to the resources and wealth of the country by yielding us oil for the production of light and heat.

It is not of the application of oil as a fuel for the great industries that I come here to speak, but of some minor uses to which such fuel is particularly adapted, and which require no revolution in any great industry, but which will aid all industries. I believe such introduction of liquid hydrocarbons for producing light and heat is but "the thin edge of the wedge," and will ultimately lead to its ultilization in the great business of the nation. The attempts which have hitherto been made to obtain light from oil have led to the belief that no useful light can be had without the aid of an artificial draught. The trouble and care required in managing such lights rendered the introduction of gas—as an illuminant which required no artificial draught—a real boon, and soon the world came to know what a comfort it was to have the house well lit on the long, dark winter nights. Soon the light of the house was used in the workshop; but as operations gained in magnitude, gas was found to be quite unequal to the work demanded of it, and, more especially for out-door operations, the want of a good light began to be keenly felt.

The electric light at first bade fair to supply the want, but soon it was found that its very beauty and intensity were the cause of its uselessness for ordinary workshop operations; and I have often seen a workman at his lathe using the antiquated tallow candle, to appreciate the details of his work, right underneath the dazzling glare of an arc lamp.

Now, the first use of the exhaustless store of oil in the earth's crust, which I am going to illustrate, is its use for yielding a powerful diffused light, for conducting difficult work during the darkness of our short winter days and long winter nights. The fundamental difference between a gas flame and one from oil lies in the fact that the gas contains much less carbon, and when the hydrogen burns there is so little carbon set free that it is completely burned away to carbonic acid, as it reaches the outer portion of the flame. The greater proportion of carbon in the oil causes the carbon to be set free in a much denser form, and the paucity of hydrogen makes the temperature of the flame lower, and the combustion of the carbon is incomplete. Hence smoke arises.

To obviate this, artificial draught has been resorted to, by placing a funnel over the flame, and so causing the air to impinge at the root of the flame, or the same effect has been attained, as in the "Empress" lamp, by means of a small fan. When it came to producing large flames, the matter of dealing with the wick and draught became much more difficult, and when a light was wanted for outside purposes, all arrangements with glass funnels were impossible, while such a weak blast as could be used for supplying oxygen to this flame was at once reversed and the flame extinguished by the slightest breeze of wind. What is required for an open air illumination, unprotected by glass, is such a mixture of hydrocarbon and air as will set free only as much carbon as will be consumed by the time it reaches the edge of the flame, and a flame of such pressure or stiffness as will resist the wind. A type of the first condition is found in those gas producers whose action depends on passing air through some of the volatile hydrocarbons, when the air takes up sufficient vapor to yield the amount of carbon on combustion to give luminosity like coal gas. Yet the bulk of that gas is air. Now, a carbureted air may be closely imitated by intimately mixing finely divided liquid hydrocarbons, or even solid hydrocarbons, with air, the state of division being so fine that the hydrocarbon may be said to be equally distributed throughout the air. When such a mixture is fired, the heat of the initially burning hydrocarbons volatilizes the remaining hydrocarbons, and produces that mixture of hydrocarbon vapor and air which closely imitates coal gas. But with this important difference. The blast required to disintegrate the oil is such a powerful one that the flame is rendered very stiff, and resists the deflecting power of the wind, so that the naked flame thoroughly illuminates a space as well during stormy weather as during calm. Now, that is the great desideratum of an outdoor light. Besides this, the amount of air supplied for combustion is in no way dependent on the draught created by the lamp, but can be varied to the most extreme proportions at will, so that such a lamp will burn any kind of hydrocarbon, from the most volatile naphtha to the thick tar, which requires to be warmed to flow. In fact, any of these hydrocarbons may also be burned either so that no free carbon is given off, and hence the flame is non-luminous, like a Bunsen flame, or it may be given less and less oxygen, its luminosity increasing until the point is reached where it begins to give off unburnt carbon, and smoke is produced.

Then such is the force of the escaping mixture of spray and air that the flame may be propelled in any direction, vertically upward or downward, horizontally or slanting, and it takes the direction in which the burner is pointed without the slightest deviation. It will be clear that this flame possesses properties and has a range of adaptability such as are possessed by no other flame; and I propose to illustrate to you in what manner these important properties may be made available for some uses in the arts.

The conditions necessary for the production of light from any hydrocarbon are the presence of just sufficient air for the combustion of so much of the hydrogen and carbon as shall raise the temperature of the residual hydrocarbon to the point of dissociation, so that carbon may be set free in the flame. The carbon so set free glows and radiates both heat and light, and as it passes up through the flame, it must reach the outer edge at such a temperature as will insure its complete combustion in the free air with which it comes in contact. In coal gas, which is poor in carbon, these conditions may be brought about by merely spreading the gas into a thin film, and igniting it, but in oils or hydrocarbon vapors the amount of oxygen thus supplied is too small, and it is necessary to urge a blast of air against the flame to prevent smoke. But there is a class of oils which contain so very much carbon, and are so easily decomposed, that even the heat of the flame at the wick of a lamp will cause them to deposit carbon, and even the best draught produced by a funnel will not bring sufficient oxygen into contact with their flames to prevent smoke. In the case of such oils, the only method of obtaining smokeless flames is by causing the air to mix with the vapor throughout the flame, and, by preference, using hot air. When this is done, a very thick flame may be used, and this constitutes a most important feature of the new method of producing light, which I am about to explain to you. It has been shown that the carbon set free in a flame is either only a very dense hydrocarbon in the gaseous state or, what I think much more probable, is carbon in such a molecularly fine state of division that it passes the vibration of light on just as though it were a transparent body, so that the thickness of a flame does not to any extent obstruct the light passing out from its center. Now, provided that this thickness can be obtained without the production of smoke, it is a very important property of a flame, because each particle of carbon travels for a longer time incandescent, and because a large body of flame can reach a higher temperature than a thin body exposed to cold air. Thus we get not only more light emitted by each particle, but that light is emitted for a longer time.

Now, as to the apparatus for bringing about this result. After a long series of experiments, extending over several years, and involving the construction of very varied forms of apparatus, the inquiry has gradually become narrowed down till a form has been reached which gives all the results that could be expected from the crude hydrocarbons with which we deal, and which yields a beautifully clear light from any oil, up to coal tar as thick as treacle, provided it is free from water.

THE LUCIGEN.

The common form of the apparatus, which has been called the lucigen, and which is wrought by compressed air, is illustrated at Fig. 1, and the oil is contained

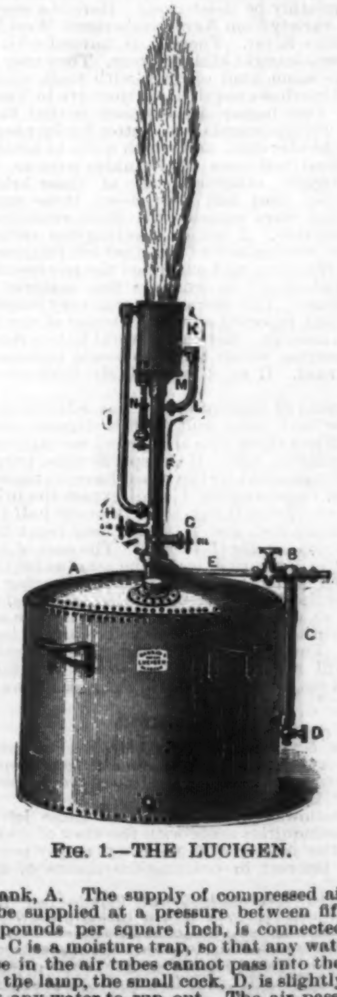


FIG. 1.—THE LUCIGEN.

in the tank, A. The supply of compressed air, which should be supplied at a pressure between fifteen and twenty pounds per square inch, is connected to the tap, B. C is a moisture trap, so that any water which might be in the air tubes cannot pass into the oil. In starting the lamp, the small cock, D, is slightly opened to allow any water to run out. The air passes in by the tube, E, and has access to the oil tank, where it

presses on the surface of the oil in A, and forces it up the central tube, F, to the burner, the flow being controlled by the valve, G. The supply of air for disintegrating the oil and aiding in combustion passes through the controlling valve, H, and up by the side tube, I, to coil superheater, K, where it circulates round the flame and gets highly heated. This superheater also protects the root of the flame from violent gusts of wind when the lamp is used for engineering operations in the open air. The form of this superheater has been altered many times, but this answers all purposes best. The heated air passes down by the tube, L, and into the burner, where it surrounds the oil tube, and hence warms the oil before it reaches the burner. This is important, as the crude oil thickens in cold weather, and stops the burner. The burner, M, consists of two concentric cones, the inner one containing the oil, and the outer the hot air, and these issue as a spray mixture into the combustion chamber, N. This latter is a most important part of the burner, and is shown enlarged at Fig. 2, a view, and Fig. 3,

FIG. 2.

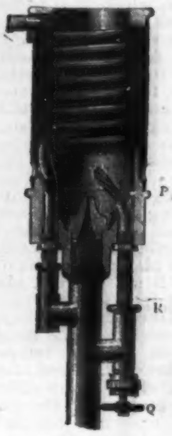


FIG. 3.

a section. It will be seen that the chamber has three walls, and the air enters through the perforations at the bottom of the outer wall, passes up between the outer and middle wall, and down between the middle and the inner wall, and below the edge of the latter to the flame. The inner chamber is formed bell-mouthed, in the form of an aspirator, and a powerful draught of air is sucked in and delivered at the root of the flame. The narrow part of the bell-mouthed combustion chamber soon becomes red hot, and as the form of the chamber leaves a larger space here than at any other part of the course, the air moves slowly here, and has time to get thoroughly heated, so that the form of this chamber serves two purposes. The result is a powerful jet of mixed spray, hot air, and hydrocarbon vapor, driven out by compressed hot air, and surrounded by an aspirated sheet of hot air derived from the atmosphere. When this is ignited, it forms a cylinder of flame, tapering at both ends, about three feet long by nine inches in diameter at its widest part, and of an intense whiteness, without the slightest vestige of smoke or smell. The apparatus above described is suitable for open spaces and workshops where a lateral diffusion of the light is wanted, and modifications of the apparatus have been prepared which enable it to be adapted to almost every kind of building and work. When a local light is wanted for illuminating any machine or small space, a smaller apparatus has been constructed, to yield from 400 to 800 candle power. This is constructed exactly on the lines of the larger lamp. The form of the flame being that of an elongated cylinder causes it to radiate much more light, and light of a much more diffusive character, in a direction at right angles to its length, than in any other direction. Hence when required for lighting a large radius on a level with the flame, the vertical flame is used, but when the light is wanted to illuminate the space underneath, a horizontal flame gives much greater duty for the same consumption of oil. As already mentioned, the great pressure at which the lucigen is worked enables the flame to be driven in any direction, and hence a horizontal flame, as shown in Fig. 4, is as easily obtained as the vertical. This form of flame exposes a large radiated surface to the space underneath, and is the best form for lighting up machines or work on the floor of a shop. This is a new departure in lighting, and is found to give admirable results. Where roofs are very low, or for lighting the bottoms of ships in dock, the horizontal lucigen, shown in Fig. 4, is also specially suitable. Sheds only 10 feet high, and with wooden roofs, can be efficiently and safely lighted up by means of this horizontal burner; and as it casts its flame out at about 20 inches from the ground, the bottom of a ship in dry dock can be beautifully lit up by placing one of these lights on the ground on each side of the ship. Where the apparatus is placed against a wall, and intended to light the machinery beneath, while also yielding a light all round, the flame is given an angular direction, so that no shadows are cast underneath.

When a work has to be lit up permanently, and the separate oil tanks might be in the way, the oil may be kept in a single large tank, which is placed preferably on the same level as the lights, and the oil and air are led separately in tubes to the various burners. The oil in the main tank is placed under the air pressure, and thus acts at the burner just in the same way as it would were it supplied in separate tanks.

Where a large illumination is required to be thrown over an irregular surface, or in a yard where structures are being built, the lucigen is arranged in triplex form, and the illuminating of each burner is considerably increased by the intense heat this arrangement develops. The total light is from 9,000 to 11,000 candle power *actual*, and it produces an illumination unapproached by any method of producing light hitherto invented, and only to be compared with a conflagration.

When a number of lights are fitted up in a work, the labor of filling the tanks by pumping is considerable if performed by hand. To obviate this a portable tank

FIG. 5.—THE LUCIGEN.

has been prepared, which is filled with oil, and wheeled to a position underneath the tank. A tube is led from the bottom of the portable tank to the lucigen above, and the compressed air is admitted to the top of the portable tank, when the oil is forced up to the tank. In this way the lucigen may be speedily and easily filled.

The size of the flame given by these lamps is so great that the shadows are all nebulous at the edges, and the volume of light, if I may so call it, is so great that the reflection from surrounding objects lights up the shadows, and prevents that blackness of shadow so troublesome with the electric light. At the same time the flame may be made of any smaller size by simply turning the valves, G and H, Fig. 1, so as to cut off more or less oil and air.

The flame cannot be blown out by any wind, because while a strong wind may bend the flame, and a hurricane may scatter it, the formation of the combustion chamber keeps the root of the flame thoroughly protected, so that no wind can extinguish it. But it may happen that, in spite of precautions, the crude oil used contains drops of water, derived, perhaps, from imperfectly drained casks or other causes; and as the class of oils used for the lucigen are nearly of the same density as water, such drops do not settle, but pass into the burner with the oil. When this happens a gap is caused in the flame, and it is extinguished. In order to prevent such accidents, the arrangement, P Q R, in Fig. 3, is used to relight the flame. It consists in an independent supply of oil passing through the connection, R, and regulated by the small screw valve, Q,

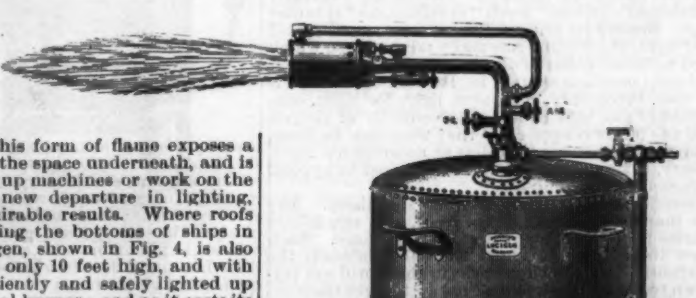


FIG. 4.—THE LUCIGEN.

passing up by a tube to a burner, P, which has a wick composed of asbestos and wire. The amount of oil passed is very small, and the heat is so great that most of it is volatilized, and keeps a small gas flame burning at P, which relights the main flame in cases like those I have stated. In most cases it is never required, but it gives additional security to the constancy of the flame.

There is one use to which I hope to see the lucigen applied, in which this relighting arrangement would be very useful. I hope, before many years elapse, every ship which crosses the great highway of the Atlantic, or makes for our ports through our crowded channels, will carry, instead of the red and green lights so often invisible or deceptive in a slight haze, one or two lucigens, which will light up the ship and the surrounding sea so clearly that the masts, spars, and hull of the vessel will be visible for miles, for it must be remembered that the great flame renders clearly visible surrounding objects, and does not give the blinding glare of the electric light, which renders all but itself invisible, and thus the approach and course of that ship will be as apparent as in broad daylight. Were such an arrangement carried out, the mysterious disappearances of so many fine ships would, I believe, be greatly diminished in number. The relighting arrangement would admit of the use of a push stop valve being applied to the main oil supply, and any one acquainted with the Morse alphabet could telegraph to a passing ship by the dot and dash system, by means of this key stop valve. When the main flame was extinguished for the period of darkness, it would relight itself at the messenger, which is invisible.

From the description of the apparatus already given, it will be seen that a large proportion of the air required to support the combustion of the oil is drawn

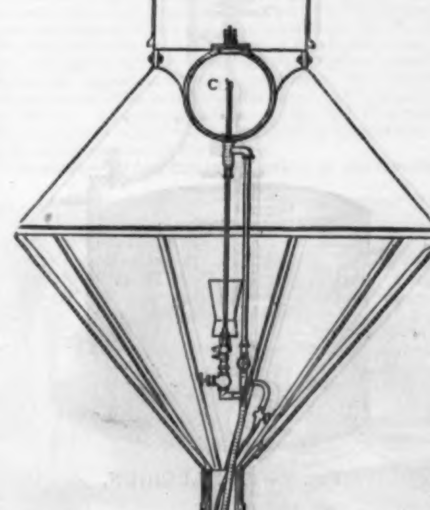


FIG. 6.

in by aspiration, so that when steam is used instead of air as the disintegrating medium to form the oil spray, its choking effect on the flame is very small, and the light appears to the eye to be almost as good as when the air is used. When steam is used, however, the apparatus cannot be arranged for the pressure of the steam to drive up the oil, as is the case when air is used, because the steam must not be allowed to come into contact with

the oil, as it would destroy it for burning. The steam lamp must therefore be arranged either so that the oil will flow to the burner by gravitation, or that it is forced up to the burner by the pressure of the steam supplied to an extensible chamber contained inside the oil tank. In this case the condensed water formed in the tubes between the boiler and the lamp is led into this chamber, so that it is filled with water backed by steam pressure.

In earlier patents the oil was raised to the burner in steam lamps by suction, the burner being formed like an ejector, and the oil so aspirated was burned with its mixture of steam. The great volume of the latter required to aspirate the oil choked the combustion so much that the flame became yellow, and much oil passed through the flame unconsumed. This is fatal to any light, because the finely divided creosote floats in the air and causes the eyes to smart, and objects all around get a shower of tarry oil. In the lamp under consideration these troubles are all carefully avoided.

In Fig. 5 is shown an arrangement for the supply of oil by gravitation, and as the fall of the oil is so very short, and the pressure hence so slight, the burner is arranged with the steam in the middle of the oil, and the opening for the latter rather large, so that the flow may be sufficient for a large flame.

The heat from the lamp may be further utilized to raise steam to disintegrate the oil, and in Fig. 6 is illustrated this form of apparatus. It will be apparent that it is impossible to start this lamp with steam, as until the flame is started there is no heat by which the steam can be raised. It can be started, therefore, either by a hand pump or by the following simple contrivance. The water is allowed to run into a tank underneath the ground until it is half full, when the imprisoned air will have acquired a pressure of 15 lb. on the square inch. The water is now turned on to the extensible water chamber in the tank containing the oil, and the air and oil being now under the proper pressures, the valves are turned on and the lamp lit. In about forty seconds the copper chamber, C, is hot enough to produce the steam, and the water is now turned gently on until steam issues freely from a small try cock at the base of the burner.

As soon as the steam issues dry the cock for the admission of the air is closed, and the lamp will now run perfectly steadily as long as the oil lasts. Of course, as the flame must impinge on the copper, C, this form of lamp must be inclosed in a lantern, to protect it from the wind.

Where a supply of water at a reasonable pressure can be had, the compressed air may be supplied from a pump driven by a small water motor. Apparatus of this kind has been used with great success.

Where, for outside purposes or for fixed workshop purposes, regulation of the size of the lucigen flame is not required, the earlier forms of the apparatus may be used. In this form (Fig. 7) the air supply with

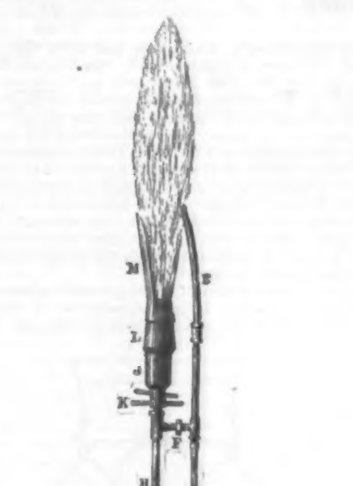


FIG. 7.—THE LUCIGEN.

moisture trap is arranged much the same as in Fig. 1, but the air passes by the India rubber tube, O, to the vertical superheater, E, which is a double tube. The air passes up the inner tube and returns down the outer tube, E, which is of copper, and through by the union, F, to the burner. The tube, H, which supports the burner, is also double, the inner tube passing right to the bottom of the tank, and being thus immersed in the oil.

The compressed air passes down the outer tube, and pressing on the surface of the oil in the tank, drives it up the inner tube to the burner. The regulation is performed by turning the burner, J, which has a cone ground accurately to fit the cone of the inner oil tube. By this means the air and oil are regulated, because if the burner is screwed up the air gets freely to the outer cone and presses back the oil, while, if it is screwed down, the air is checked and the oil comes more freely. When the flame has been properly regulated, the jam nut, K, is screwed hard against the burner, which is thus held firmly at the required regulation. The burner in this case is not of the hot air aspirating pattern, but simply a closed burner.

A form of lucigen is also arranged for a break-down plant, with a portable compressor and receiver, which can be wrought by two men. This form of the apparatus was largely used in the recent mobilization experiments by the French government, as it was found to be much superior to electric lighting for training horses and drilling troops at night.

The characteristic of all these lamps is that they yield an intense white flame of about 2,500 actual can-

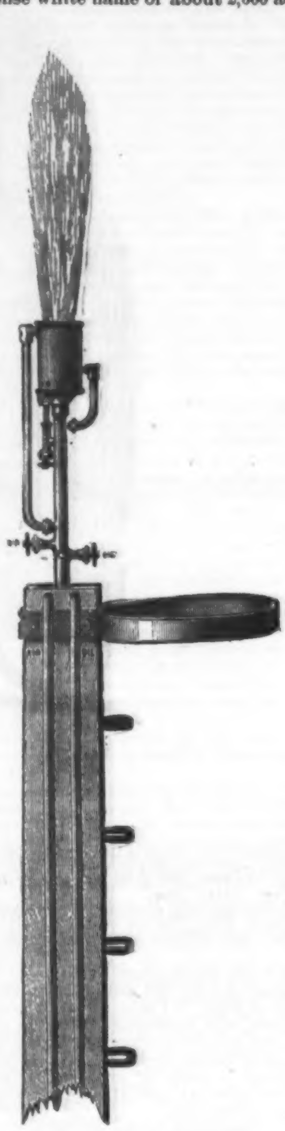


FIG. 8.—THE LUCIGEN.

dle power with a consumption of two gallons of crude oil per hour. I say actual candle power measured by an ordinary gas tester's photometer, because we hear so much of so many candle power "nominal" in the case of electric arc lights, that I think, once for all, illuminating power should be honestly stated by the best standard known. In trying the lucigen flame near a group of four electric arc lamps of 2,000 candle power "nominal" each, it was found, to my great astonishment, that the lucigen was much brighter than the four arc lamps put together.

As it was yielding about 2,500 actual candle power, it follows that each 2,000 "nominal" electric arc was really under 600 candle power. Such "nominalness" is rather striking. Besides its great diffusive power and broad glow of light, the lucigen has many advantages, which have led to its adoption in all the important engineering and ship building centers in Britain. The first is its low cost, being only, compared light for light, one-tenth that of gas, and hence one-twentieth of electric light, if the latter is applied so that work can be done, because the electric arc is useless as an artisan's light. Electricity, to be of use for detail work, must be applied in the incandescent lamp form.

The second advantage is its extreme simplicity. Any one can manage and regulate the light, and any failure must arise from some easily discoverable cause. Such has been its success in a short time, that already the most extensive engineering works in the world are laying down tubing for the compressed air to light their entire works, while their expensive electric lighting plant will be disposed of in the way which will entail the least loss. Railway companies have laid down this plant for lighting their shunting operations at night, and by leading both oil and air, under pressure, in tubes to the burner fixed to a post, the light may be produced at long distances from the sources of oil and air. Already the system has been extended half a mile from the compression pumps, and it will soon be extended to over a mile. This system is thoroughly suitable for lighting cities, the motive power being small steam or gas engines at suitable intervals. The apparatus as at present used by some of the leading railway companies in this country is illustrated in Fig. 8.

This brings me to the second part of my subject—the production of heat from oil.

In the first place, I may remark that we have been so long accustomed to use coal for producing heat, that the methods hitherto followed in regard to oil have been simply slight alterations in the forms of furnace already in use for coal. It will be plain, however, to any one that the two cases are entirely different, and inasmuch as the oil leaves no ash, requires no supporting bars, and can be introduced anywhere in the furnace, I think that the old forms of furnaces are bound to be entirely abandoned before really good results can be obtained from oil. Therefore, the apparatus I am about to describe to you is, I may say, merely the results of the first crude trials in the direction of the proper utilization of oil for producing heat, and although highly successful as far as yet applied, I feel that for larger operations much better and more economical furnaces will yet be invented.

The first point which strikes one about the use of oil for heating is, that there are many operations for which small isolated sources of heat are required, such as the multitudinous articles manufactured out of bar and sheet iron and steel, which require to be stamped, punched, or shaped while still hot. For all these purposes the oil furnace is especially suitable, and as each furnace must be constructed for the special purpose to which it is to be applied, I shall describe one form as typical of the method, the other forms being merely varieties.

The form I shall describe is that used for heating rivets for modern riveting machines, shown in Fig. 9.

This furnace being specially designed for the economical and quick application of heat, has been called the pyrigen, or fire producer.

In my earlier experiments, it was attempted to apply the principles which Siemens laid down for coal furnaces, *i. e.*, regenerative action in the furnace, and allowing the flame to do all its work by radiation, touching the brick as little as possible. A furnace constructed on these principles acted very fairly, but on comparing the heat obtained with that produced by merely playing the flame into a confined brick space, where it got churned about, it was seen that to this sort of fuel Siemens' rules for the economical production of heat from coal did not apply. He taught that whenever the flame touched brick, it underwent dissociation, and the temperature attainable was very much lowered. Now, after a long series of experiments, during which many different forms of furnaces have been constructed, the conclusion has been irresistibly forced upon me that in the kind of flame with which we are dealing, the more the flame touches the brick, the higher a temperature we get, and my whole ingenuity is spent in doing absolutely the reverse of what Siemens advised, namely, in devising furnaces in which the flame is baffled by the form of the brickwork, and churned about, and, as it were, rubbed against the brick as much as possible. It is found that a furnace constructed after this plan may be maintained at the same temperature as a Siemens' furnace of the same size, with a combustion of only one-fourth of the amount of oil.

The results obtained by this furnace are somewhat remarkable. On first turning on the oil, the flame is simply like the lucigen, and the rivets may at once be heated by heaping them up in front of the flame. But as the furnace heats up the flame becomes larger, and, if the flow of oil be not decreased, it would pass round into the chimney and produce smoke. As the oil supply is diminished, the flame becomes more and more transparent, till a point is reached when "flameless combustion," so well described by Mr. Fletcher, of Warrington, is obtained and the inside walls of the furnace simply glow with a white heat without any visible flame. This is the most economical form of furnace heat, as the gases only combine when touching the solid surface (and yet do not wear that surface like an impinging flame), and hence the furnace glows with an intense quiet heat, which quickly raises to a high temperature any articles exposed on its floor.

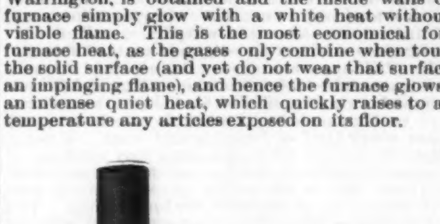


FIG. 9.

The atmosphere to which the articles are exposed in this furnace is one which, from its peculiar character, is well calculated to preserve the articles from oxidation or other deterioration. It contains no sulphur, no dust, and no free oxygen, as the oxygen is all required to combine with the hydrocarbon of the oil, and hence iron or steel may lie there for hours without being in any way destroyed.

In all other operations requiring quick heating with purity of atmosphere the pyrigen flame is peculiarly well adapted, and the following may be mentioned as some of its various uses:

It is specially well adapted for heating iron, for making bolts, rivets, and nuts, and has many advantages over the ordinary rivet iron furnace. There is no loss from destruction of fire bars or bricks, and no dust and ashes, while the cost of oil required for combustion is not one third that of coal, the iron at the

same time being maintained in its pure condition, and not burned nor sulphurized as when coal is used.

The increasing use of fixed and portable riveting machines in ship building, bridge building, and other engineering operations, calls for an economical and systematic method of heating rivets as a matter of the highest importance. The pyrigen is admirably adapted for this purpose, as by its use the rivets can be regularly supplied in any quantity to the machines at the required temperature. The furnace can be made ready for use in ten minutes, and the temperature kept steady, and under perfect control, while the iron is in no way injured, and the rivets are not subject to the usual percentage of loss which takes place when coal is used for heating. Further, the pyrigen, being portable, can be readily shifted according to the requirements of the work—all that is required being a connection to a supply of compressed air.

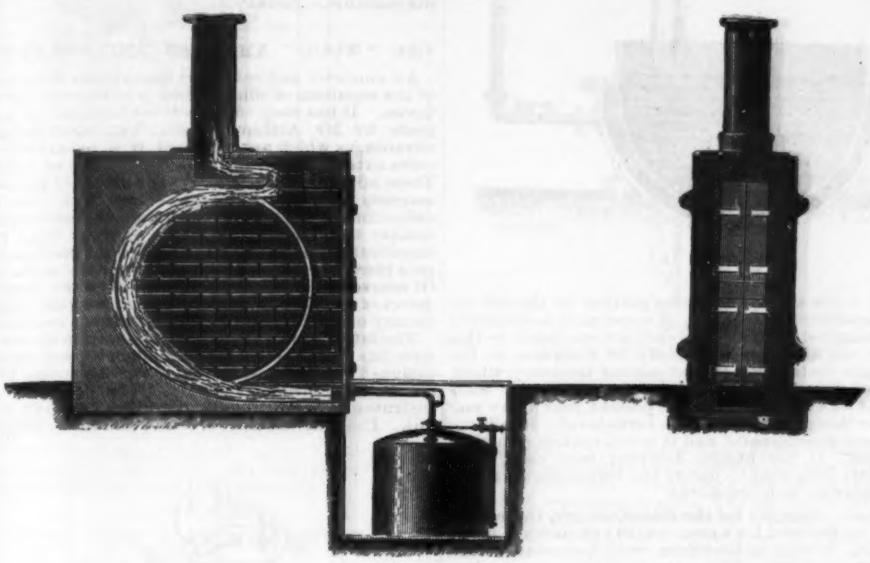


FIG. 10.

Another useful application is for heating the steel or iron tires for shrinking on to the wheels of railway carriages or wagons and ordinary coaches, the labor and expense of the usual methods of heating being superseded at much less cost, as the pyrigen can be got ready for heating in a few minutes, and the flame turned off when not wanted. Fig. 10 shows the pyrigen arranged for heating coach tires.

It can also be effectively and economically adapted for angle iron and plate reheating, as employed by boiler and bridge makers, and is greatly superior to the ordinary furnaces, as by its use the heat can be regulated at pleasure, and the iron kept clean and free from scales.

The horizontal form of pyrigen is also suitable for a great variety of other heating purposes, as metals treated in this furnace can be raised in a very short time to a welding heat; while their purity and tensile strength are not in the least degree injured, as the atmosphere is entirely free from either sulphur or phosphorus, and no carbon is present in any form which would enable it to combine with or deteriorate the iron.

This form of furnace is also well adapted for cupelling and other special metallurgical operations where a high temperature and purity of atmosphere are required. The sharpness of the heat of this little furnace may be judged from the fact that a cold brass casting of several pounds weight thrown on the hearth began

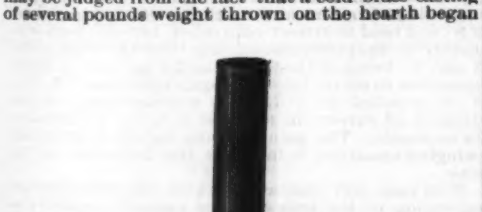


FIG. 11.

to melt in 45 seconds, and was completely liquefied in 55 seconds.

Fig. 11 illustrates the vertical form of furnace for heating crucibles, as in brass founding, fluxing, bullion smelting, etc., and conducting other operations where it is desirable to surround the object with flame either of an oxidizing or a reducing character. The capabilities of such a furnace may be learned from a trial of brass melting in a crucible. The crucible, 8 in. by 12 in., was put in cold, filled with broken brass castings, and the whole brass was liquid, and, in fact, much too hot, in twenty minutes. Of course such rapid heating cracked the crucible. Starting with the crucible of the same size hot, the brass was liquid and ready for pouring in four minutes and a half. This constitutes a most important advantage of the pyrigen over heating by coal or coke, as by merely turning a tap the flame may be changed in an instant from oxidizing to reducing, or *vice versa*, while the temperature can be raised to any given point, and be maintained there perfectly steady for any length of time.

This absolute steadiness with which any given temperature may be maintained renders the pyrigen very valuable in such operations as japanning, vulcanizing, annealing, etc., all the arrangements being of the simplest nature.

As in the case of the lucigen, it can be wrought by compressed air or steam, the best and most economical results being obtained by the use of the former; but where compressed air cannot be conveniently had, steam may be used, it being superheated by passing through the flue before reaching the burner.

Any kind of crude oil, creosote oil, tar oil, or gas tar, may be used in the pyrigen, the oil tank and service pipe being so arranged that the oil or tar is gently heated before combustion.

In Fig. 9 the oil tank is shown so arranged that the oil flows by gravitation to the burner; in Fig. 10 the tank is shown having a jet of compressed air applied to it to force the oil to the burners. Either method can be used, but the former is necessary when steam is used for disintegrating the oil.

The pyrigen burns without smoke or smell, and as it gives off no irritant gases, it can be used inside an ordinary engineering shop without the slightest inconvenience, while the burner and tank are constructed similarly to the lucigen, and may be used for lighting the workshop when not in use for the furnace.

Before closing, I may briefly refer to the use to which oil may be put when the vast stores have been opened, and the distribution effected in an economical way. At present the limited quantity at our disposal renders the use of oil for steam raising for ordinary commercial purposes quite out of the question, because the amount required for even a few Atlantic liners would exhaust the supply, and raise the price beyond the economical limit.

But there are special circumstances in which it is desirable to raise steam with as small a weight of fuel as possible. The modern torpedo boat or fast cruisers are vessels in which the saving of weight in the fuel used is of far more importance than the price of the fuel. This consideration caused me to conduct a series of experiments on a land boiler of locomotive type, with the unexpected result that 6 cwt. of oil fuel raised as much steam as had been raised by one ton of small coal. This unexpected result, showing an efficiency of three times that of coal, caused me to look into the conditions under which heat is obtained from the two kinds of fuel.

In the case of coal the combustion is irregular, and the average temperature of the gases passing up from the fire may not be over 1,000° C., while, owing to the constitution of a coal fire, and the easy formation of smoke, large quantities of air require to be heated which take no part in the combustion of the fuel, in order to provide an excess of oxygen to consume the smoke. In the case of oil as consumed with my new burner, the combustion is quick and perfectly regular, and the exact amount of air required for combustion is heated, so that there is no waste, while the average temperature may be 1,000° C. higher than in the case of coal, and hence the available heat immensely greater. Hence, it is not a question of the amount of energy in oil as compared chemically with coal, as they are nearly equal, but it is a question of the amount of available energy to be had from the fuel, an amount which depends entirely on the conditions of combustion of the fuel, and, in this respect, oil is greatly superior to coal.

The "available heat" is the amount of heat absorbed by the boiler and communicated to the water, and is represented by the difference of temperature between the gases immediately over the burning fuel and that at which they pass away to the chimney. As the latter temperature is practically the same with equal volume passing away, but is lower with a smaller volume, it is plain that the higher the initial temperature of the gases, and the smaller their volume, the greater is the duty of the fuel.

In oil fuel, as dealt with by my new burner, there is a very high initial temperature, and the gases are reduced to the minimum, which will carry on complete combustion, so that the conditions are secured for a very high state of efficiency.

I have here roughly sketched types of the two important uses to which the immense reservoirs of oil in the earth's crust may be applied, and, no doubt, when these stores are properly worked, and the contents distributed over the globe as efficiently as wheat is at present distributed to hungry nations, the light and heat of the future will mainly be obtained from oil.

[At the conclusion of the reading of the paper a lamp of the smallest size was shown in operation.]

BOTTLE CORKING MACHINE.

THE engraving represents an improved bottle corking machine, which is specially suitable for corking

BOTTLE CORKING MACHINE.

beer, wine, and spirit bottles. The makers, Messrs. Downing & Co., Sackville Street, Manchester, state that this machine is capable of corking about one hundred dozen bottles per hour. A cork is placed in a recess immediately below the plunger, and the bottle to be corked is put on the cylindrical stand. The handle, shown in the illustration, is then pulled down, causing the plunger to compress the cork, while at the same time the bottle is forced up to the compressed cork, which is thus driven home. When released, the handle again falls into its normal position. In some cases the handle is replaced by a treadle motion.—*Industries.*

[Continued from SUPPLEMENT, No. 626, page 9998.]

WOOL HAT MAKING.

DRYING.—The required size having been secured, the hat bodies are next thoroughly dried. For this purpose a room furnished with boilers to constitute the flooring answers admirably. In addition, a few light racks are fitted up, and a drying room sufficient for all practical purposes is thus economically constructed. The degree of heat used is of little consequence, provided it is not less than 100° F. At a temperature of, say, 150° F. a period of about twelve hours would ordinarily be allowed for the thorough drying of the bodies.

PROOFING.—So far, the body exists in the condition

FIG. 8.

of soft felt. To impart that stiffness which is characteristic of low-crowned hats, the hat body is at this stage treated with a solution of stiffening matter, or "proof." Two processes are required here, since the brim, which in actual wear is subjected to frequent handling, must be made firmer than the body. Fig. 8 shows two men

at work in the act of proofing. The first man, who confines his attention exclusively to the brim, takes hold of the body, and immerses the brim in a pail containing a very strong proofing solution. Then laying each body flat on the inclined "plank," he uses a wooden scraper, for the double purpose of working the proof into the fabric and removing the superfluous solution, which then finds its way into a tank.

The second man then receives the body, and plunges it into a similar tank, containing a solution of less density, to impart the lesser stiffness required in the crown. The scraping is then repeated. The proofing solution is composed of shellac, resin, borax, and gum thus. Great care is exercised in the preparation of proof, and its density is carefully ascertained previous to use. The exact proportions in which the ingredients are used is a point of considerable importance. A microscopical examination of the fabric at this point shows that each fiber of wool has in the operation of proofing received a complete coat of fine varnish.

FIG. 9.

STOVING AND STEAMING.—In order that the proof may permeate the entire fabric, the hats are now subjected to another heating operation. For this process a second hot room is provided, in which the bodies are subjected to a temperature of 180° F. Immediately adjoining this room is arranged a steaming box of the kind shown in Fig. 9. The hats are removed from the stove, and are placed in the box, where they are subjected for about thirty minutes to the action of steam, supplied by a pipe direct from the boiler at a pressure of from 70 lb. to 80 lb. The object aimed at by the introduction of hot moisture at this point is to secure the necessary nap on the external surface. The bodies are then reintroduced to the stove, and are kept at a temperature of 180° F for three hours, so that the gums may be thoroughly set and dried.

FIG. 10.

PULLING OUT.—The crown of the hat is a part which requires considerable attention throughout the process of manufacture. There is a tendency to mill up at this point, and the operation of "pulling out" is an operation which has to be performed in order that perfect equality in the thickness of the entire body may be obtained. The machine used for this purpose, and which is shown twice in Fig. 10, is called a stretching machine. A hat body is placed over a skeleton block, the ribs of which are capable of being compressed as it enters its cup. The action of compressing the lower ends of the ribs tends to expand the crown or tip of the hood, so that while the lower or rim portion of the hat remains unaffected, the crown, or upper part, is subjected to a thorough stretching. The ends accomplished by this machine are to insure uniformity of thickness in the fabric and destruction of that conical tendency which the crown is apt to assume if not dealt with by some means of this kind. During the present year a new machine for this purpose has been introduced. Its action, we believe, is automatic, and it is well spoken of in general terms. It has hardly, however, been used for a sufficiently long time to justify the formation of a conclusive opinion as to its merits.

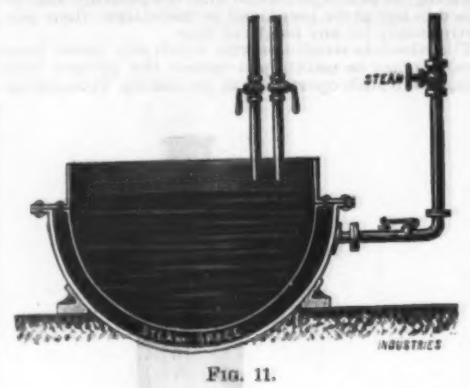


FIG. 11.

DYEING.—Happily for the manufacturer, there is at present no demand for a great variety of colors in men's hats, and dyeing is, therefore, only necessary within very narrow limits. The only popular color to-day, besides black, is brown; and existing methods seem quite inadequate to secure anything approaching certainty as to the shade which a known combination of ingredients will produce when put into the vat. If this difficulty were overcome, there appears to be no reason why greater variety of color should not be introduced. The black color now commonly employed is the worst that could have been devised for hot weather, and there is, therefore, some scope for real improvement. Furthermore, the importance of variety, in the case of any manufactured article, is considerable, and always exerts a large influence upon the demand. We will describe the ordinary method of black dyeing. There are other methods in operation, and in some of these the use of mordants is introduced, and less time is consumed by the process; but these systems have not, so far, been very widely adopted. Fig. 11 shows a dye pan, which consists of an iron-cased copper vessel provided with an intervening space filled with steam at 15 lb. pressure. The black dye used is composed of logwood, copperas, and verdigris. To get the required color it is found necessary to dip the hat bodies three times; two hours being allowed for each dip or bath. After each dip the bodies are allowed to cool in the open air. After dyeing, the bodies are thrown into a vat of cold water and thoroughly washed out.

BLOCKING.—No machine has yet been introduced which satisfactorily performs the operation of blocking. In every hat that has been blocked by machine, there is a tendency to reassume the conical shape which was its original condition—the existence of which it has been the object during every preceding operation to destroy. A little heat arising from exposure to the sun, or even that which arises from contact with the head in actual wear, is sufficient to develop this unfortunate tendency in a hat blocked by machine, and for this reason hand labor is almost universally employed in this process. Fig. 12 shows the operation of blocking in four of its phases, each one of the four men shown being employed upon an independent part of the process. The body is first softened by immersion in a "blocking battery" of copper containing boiling water. It is then drawn on to a solid wood block, and is pulled firmly down on every side. At this point the brim first makes its appearance. When the block has been wholly covered with the hat body there is a considerable surplus of felt left at the edges, and this surplus is formed into a brim, in the following manner: At the margin of the block a piece of stout string is tied firmly round the hat body, and all the felt which the block has not absorbed is then flattened by the hands of the operator while the fabric is in its softened condition. The body leaves the blocker's hands in every sense a perfect hat in substance, color, and general form. It only remains to add those finishing touches which make it a marketable article.

STOVING.—This is merely a repetition of the drying operation, and is conducted in the boiler room stove, at a temperature of about 150° F. The operation occupies from four to five hours, and the object is to expel the moisture.—*Industries.*

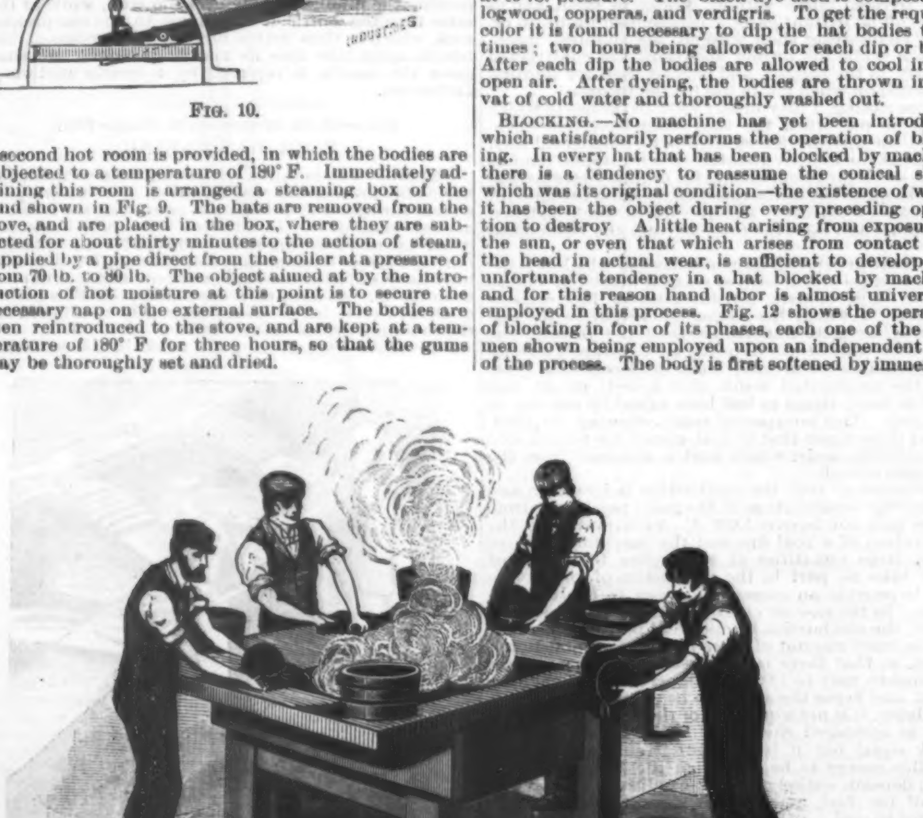


FIG. 12.

WOOL HAT MAKING.

THE "WOOD" AMMETER AND VOLTMETER.

AN ammeter and voltmeter based upon the principle of the repulsion of similar poles is not an entirely novel device. It has been employed, for instance, for several years by Mr. Arthur Wright; but, considering the advantages which are obtained, it is remarkable that more extensive use has not been made of the idea. These advantages are chiefly the absence of permanent magnets and the comparative ease with which the deflections of the pointer can be made strictly proportionate throughout the scale. This is done by an empirical adjustment of the shape and position of the pole pieces, between which the repulsion takes place. Of course the instruments labor under the inevitable defect of all soft iron apparatus, that the past magnetic history of the iron affects the subsequent readings.

The latest form in which an application of this principle has been applied is in an ammeter and voltmeter designed by Mr. J. J. Wood, of the American Electrical Manufacturing Company. The details of these instruments seem to have been very carefully worked out. The diagram (Fig. 1) shows one construction of a voltmeter, Fig. 2 showing the principal part in detail.

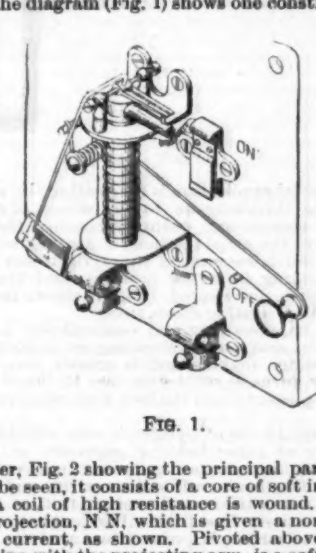


FIG. 1.

As will be seen, it consists of a core of soft iron, around which a coil of high resistance is wound. This core has a projection, N N, which is given a north polarity by the current, as shown. Pivoted above the core, and in line with the projecting arm, is a soft iron armature carrying a pointer which passes over a scale. Now, it will be seen, according to the well-known law, that the part of the armature immediately over the core of the electro-magnet will have a south polarity, S', induced in it, and correspondingly a north polarity, N', at its outer end. The consequence is that upon the passage of a current through the coil the inner ends, N S', will tend to attract each other, but are kept stationary by the pivoted armature. But the outer ends, N and N', being of the same polarity and one of them being free to move, they repel each other, and the end, N', is repelled to a distance corresponding to the strength of current in the coils, *i. e.*, the potential at its terminals. The pointer being rigidly fixed to the swinging armature, it indicates the deflection on the scale.

With pure, soft iron and working below the limit of saturation of the iron core, the magnetic capacity of the latter not only remains constant, but its strength ought to be almost in exact proportion to the inducing current. And it is a remarkable peculiarity of the instrument that the deflections on the scale are practically equidistant over the entire range. When the pointer is at the farthest end of the scale, the armature, S' N', stands almost vertical.

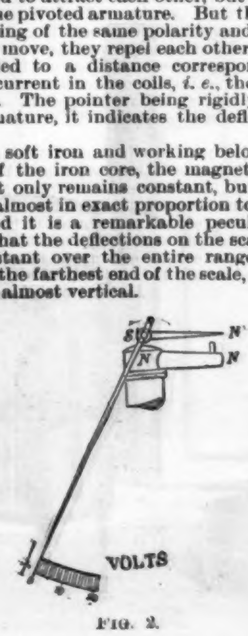


FIG. 2.

It will be noticed that the balancing force employed in opposition to the magnetic repulsion is gravity, no springs being employed.

When the instrument is set up, the pointer is carried over toward the left until the outer end of the armature, S' N', strikes the projecting arm of the electro-magnet, and then while these two are in contact the pointer is bent until it comes opposite the mark, T

(test). The armature is then released, and, swinging upward a short distance out of contact with the projecting arm, it brings the pointer opposite the zero mark on the scale. This method of testing is provided so that if, during transportation or otherwise, the pointer should become bent, it can be readily corrected so as to give accurate readings.

Another form of instrument embodying the same principle, and shown as an ammeter, is illustrated in Fig. 3. Here, it will be noticed, both poles of the electro-magnet are brought into play, and act upon

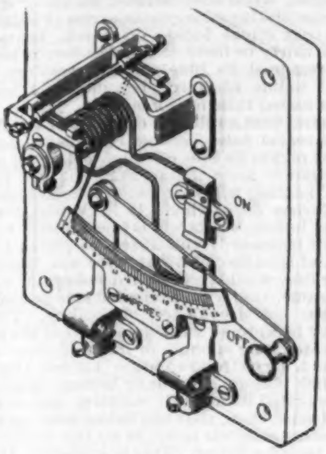


FIG. 3.

two armatures fixed to the same spindle. The action is, of course, the same as that of the instrument just described. In this form, it may also be noticed, the core of the electro-magnet is built up of Norway iron wire, thoroughly annealed, the ends carrying soft iron pole pieces, which act upon the armatures.

HOW TO MAKE A GALVANOMETER.

By C. C. HUTCHINS.

To every worker in physics or electricity a good and reliable galvanometer is a prime necessity; but the prices asked for such by instrument makers often constrain the person to get along with some rude and imperfect makeshift. I therefore propose to show how, at a merely trifling expense, an instrument may be made which shall be equal in performance to any that can be bought, and which requires but little mechanical skill on the part of the maker.

Procure a foot of 3 in. brass tubing, 5 inches of 2½ in. tubing, a half dozen disks of brass plate 3 in. in diameter, and a piece of hardwood plank, or, better, vulcanite, the latter to serve as a base to the finished instrument. From the 3 in. tube saw a piece 2¾ in. long and nicely square its ends. This is for the body or barrel of the galvanometer. Crosswise of this, and midway from either end, a slit 2 in. long and ⅛ in. wide is next to be made.

Now take the 2½ in. tube, and with a broad half-round file fit one end of it to the side of the barrel—a rather difficult feat for a novice. When fitted it is to be soldered in place, immediately over the slit in the barrel. In this and subsequent operations of soldering the joints are to be *sweat* together, that is, the pieces are bound in place with wire, plumber's acid and solder put around the joint, and the whole heated in a lamp until the solder flows into the joint, when it may be *wiped* with a piece of cloth.

Thus is formed the standard of the instrument, which serves to support it upon its base. To this end a plug of wood may be driven firmly into the open end of the standard, and a large screw passed up through

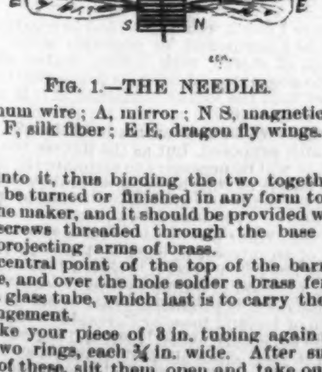


FIG. 1.—THE NEEDLE.

R, aluminum wire; A, mirror; N S, magnetic system; F, silk fiber; E E, dragon fly wings.

the base into it, thus binding the two together. The base may be turned or finished in any form to suit the taste of the maker, and it should be provided with three leveling screws threaded through the base itself or through projecting arms of brass.

At the central point of the top of the barrel drill a small hole, and over the hole solder a brass ferrule for holding a glass tube, which last is to carry the suspension arrangement.

Now take your piece of 3 in. tubing again and saw from it two rings, each ¾ in. wide. After smoothing the ends of these, slit them open and take out a small portion, so that they may just be sprung into the barrel. While in this position, with a little projecting, one of the disks is to be laid upon either ring and secured by soldering. Thus are formed two shallow cups for containing the coils. Through the center of one of these cups make a hole ¾ in. diameter, and also in each cup two fine holes, one near the circumference, the other near the center, for passing out the terminals of the coils. In the cup having the large central hole, the small hole is to be made close by the edge of the large one.

The coils themselves may next be wound. Make a spool of wood, 1 in. between the heads, and having its core ¾ in. diameter at one end, ⅝ in. at the other. The spool head on the smaller end of the core is made removable, so that the coil when finished may be drawn

FIG. 2.—THE SUSPENSION.

H, sliding wire for adjusting needle; F, silk fiber; N, glass tube.

from the spool. Pin the spool to any convenient support with a large screw, and insert a peg near the margin of the free head, to serve as a handle for turning the spool in winding the coil. The wire to be used will depend upon the purpose for which the instrument is to be employed. No. 24 to 28 wire is good for general purposes; but the general worker will find it advantageous to have three sets of coils of No. 16, 28, and 36 wire respectively, and it was that other cups and coils might be made at leisure that the extra tubing and disks were provided.

Before winding the wire is to be cooked in hot paraffin until all air is driven off. Make a small hole through the spool head close to the larger end of the core, pass one end of the wire through this hole, and then, guiding the wire with one hand and turning the spool with the other, fill up the spool, making the winding as snug and perfect as possible. To permit of adjustment, the outer diameter of the coil should be a trifle less than the diameter of the cup that is to contain it. Carefully take away the removable spool head, and without disturbing the coil give it a thin covering of *solid* shellac upon its exposed face and edge. The shellac is melted and neatly smoothed upon the coil with a hot iron. The coil may now be most carefully removed from the spool, and its other face, as well as the portion within the conical hole, coated with shellac as above. The second and subsequent coils are made in the same manner. The coils are fixed in the cups by pouring melted resin about them, first taking care to pass the terminals through the holes provided for them.

The needle or magnetic system next demands our attention, and it will test the skill of the beginner. A piece of No. 16 aluminum wire, 3 inches long, is flattened at either end for one half inch of its length, and through one end a minute hole is pierced. A staff for carrying the magnets and mirror is so formed. For the magnets procure a rather wide watch spring, anneal it well, and file or grind a portion of it until it is made as thin as newspaper, about 0·07 millimeter. Cut from this twelve pieces, each ⅜ in. long, and roll them about a steel wire into little hollow cylinders $\frac{1}{16}$ in. in diameter.*

The 12 cylinders are then to be dipped in a strong solution of potassium ferrocyanide, heated to bright red-

FIG. 3.—SECTION OF GALVANOMETER.

G G, galvanometer barrel; M M, coils; A, mirror; B B, magnetic system; C, lens; T, tube for standard; N, glass tube; R, aluminum wire; X X, terminals of coils.

ness, and suddenly plunged into cold mercury. By these means they are made extremely hard, and will retain a very strong magnetic charge. To magnetize, string them on a wire, and put in a solenoid through which the strongest available current, preferably that from a dynamo, is made to pass.

On little square scales of mica arrange the magnets in two sets of six each, taking care that in each set the poles of the individual magnets shall lie in the same direction. Secure them upon the mica scales with a very little shellac varnish, and in the same way the mica scales upon the staff, one at either end, being very careful that the combined poles point in opposite directions in the two sets of magnets. In front of the magnets near the upper end of the staff (the end having the minute hole) is placed a mirror, and fixed with shellac. These mirrors may be bought for a small sum of the dealers, or easily made by grinding very thin a piece of plate glass and silvering its unground side by any of the well-known chemical processes. The ordinary microscopic cover glasses are rarely perfect enough to be used as mirrors. Our needle now needs only the addition of a pair of dragon fly wings, in the position indicated in Fig. 1, to make it complete. These wings bring the needle quickly to rest after a displacement.

A glass tube 10 in. long is now to be fixed upright in the ferrule on the top of the barrel. A little sulphur melted upon the heated end of the tube accomplishes this. The top of the tube must be provided with an arrangement for suspending the needle. Fig. 2 shows how this is made. Another ferrule fits the glass tube. On it rests a small plate of sheet brass, which is perforated, and through the latter a split tube passes, grasping a wire, and moves in the tube with gentle friction. The ferrule, the plate, and the split tube are united with solder. To suspend the needle, remove the sliding wire and to its extremity attach with varnish one end of a long fiber of silk, such as may be drawn from white embroidery silk or a white silk ribbon.† Press a little ball of wax upon the free end of the fiber, and

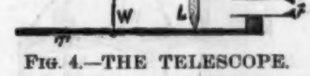


FIG. 4.—THE TELESCOPE.

T, paper tube; P, draw tube; L, lens; W, wire.

drop the ball down through the split tube into the galvanometer barrel, and push the wire in place. The end of the fiber in the barrel can now be caught and threaded through the hole in the needle staff, secured, and the wings put through the slit at the bottom of the barrel, where they should swing freely in the tube below. The coils can now be pushed into place, the coil having the large hole being the front one. In this hole a spectacle lens of 4 ft. focus, ground to a fit, is to be cemented. The suspension wire is moved up or down until the mirror is seen to occupy the center of the coil. Two of the coil terminals are to be joined so that the current may circulate in the same direction in each coil, and the other two are connected to screw posts upon the base of the instrument.

A small bar *controlling magnet* is provided, either upon a separate stand or it may be attached to the glass tube with the aid of a split cork. The instrument itself is now complete, but we need some device for reading its indications. The following simple device accomplishes that purpose better, I believe, than the most elaborate and costly telescope and scale. Procure one of those lenses sold as reading glasses. It should be about 3 in. diameter and 6 in. focus. Make a stiff tube of paper 2 ft. long, 3 in. internal diameter. The tube should be furnished with a telescopic slide at one end, and in the slide a peep hole. The lens is to be fixed in the tube at its own focal distance from the peephole, and opposite the peephole, also in focus of the lens, a fine wire or spider line is stretched. Fig. 4 shows the device in section and will make the details clear.

A scale of equal parts printed or marked upon paper and attached to a strip of board is the only remaining detail. The telescopic device is secured so as to point directly at the galvanometer mirror, about six feet distant, and a few trials will enable one to place the

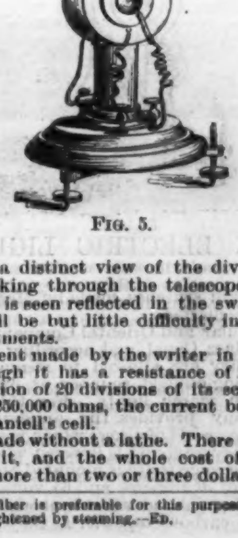


FIG. 5.

scale so that a distinct view of the divisions may be had upon looking through the telescope. Remember that the scale is seen reflected in the swinging mirror, and there will be but little difficulty in securing the correct adjustments.

An instrument made by the writer in the foregoing manner, though it has a resistance of only 50 ohms, gives a deflection of 20 divisions of its scale through a resistance of 250,000 ohms, the current being furnished by a single Daniell's cell.

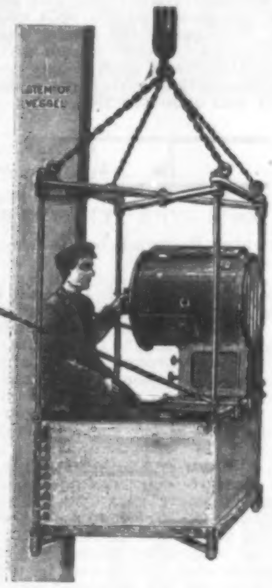
It can be made without a lathe. There is but a single screw about it, and the whole cost of construction need not be more than two or three dollars.

* Some manufacturers use short flat pieces of narrow watch spring for this purpose.—ED.

† Unspun silk fiber is preferable for this purpose, but the twisted fiber may be straightened by steaming.—ED.

ELECTRIC LIGHTING OF THE STEAMSHIPS VICTORIA AND BRITANNIA.

THE magnificent fleet of the Peninsular and Oriental Steamship Company has, during the past few years, been gradually fitted with the electric light, one vessel following another, and each having the benefit of the experience gained in those which preceded it. From the ample opportunities thus placed at his command, Mr. Hall, the head of the engineering and marine department of the company's business, has decided that success is best obtained by the use of machinery which conforms to the ideas and habits of thought of ship's engineers, and which they can take charge of without special instruction or explanation. In order to act upon this idea, it is evident that the use of all belting, wheels, and other form of multiplying gear must be abandoned equally with the various high speed engines which run in closed casings and have more or less complicated arrangements of valves. An engine as nearly of the marine type as possible, driving direct on to the spindle of a dynamo, as if it were a screw shaft, is the ideal arrangement of Mr. Hall, and this, by the progress recently made in electrical engineering, he has been able to secure for the two splendid new



vessels, the Victoria and the Britannia. As long as the minimum speed of a large dynamo was 400 to 500 revolutions per minute, its direct driving by the ordinary type of engine was subject to too many drawbacks to render it preferable to the use of intermediate gearing; but now that machines are made capable of running at 200 revolutions, and at the same time of giving a very large output, the case is entirely changed, and there is no longer the need of resorting to driving appliances which are not viewed with favor by the seagoing engineer.

The plant erected on the Victoria and Britannia by the Anglo-American Brush Electric Light Company, Limited, of Belvedere Road, London, consists of a Tangye engine having cylinders 8 inches and 16 inches in diameter respectively, by 10 inches stroke, driving directly on to a Victoria Brush dynamo capable of feeding 450 lamps. Between the crankshaft and the armature spindle is an improved form of Oldham coupling, consisting of two plate couplings with an intermediate disk. In the face of each plate coupling there are two flattened studs which take into a slot in one face of the intermediate disk, the slots on the opposite sides of the disk being at right angles to each other. A shrouding on one coupling covers the disk and studs. Thus if the two shafts should fail to lie in the same straight line, the coupling permits them both to work freely. The dynamo, which is self-regulating, has six poles, and gives its full output at 200 revolutions per minute.

The plant is entirely in duplicate, each set being capable of maintaining all the lights. The conductors from the dynamos are led to a main switchboard, and are then distributed through the vessel on the single wire system, in which the frames and plating of the ship serve as return conductors to the engine room. The lamps and groups of lamps are turned in and out by the porcelain switches made by Messrs. Dorman & Smith, of Manchester.

THE ELECTRIC LIGHTING OF THE STEAMSHIP VICTORIA.

The Peninsular and Oriental Company's vessels pass through the Suez Canal, and according to the present regulations they are allowed to steam on at night, instead of being obliged to moor at dusk, if they are provided with search lights. For this purpose the Brush Company provides the apparatus illustrated above. This consists of a cage which is suspended over the bows of the vessel and is lowered within 8 ft. of the water. In this cage there is mounted an arc lamp taking a current of 70 amperes and 65 volts. The lamp is regulated by hand by an attendant who sits behind it and feeds the carbons together as they are consumed. The beam is reflected by a mirror 22 in. in diameter and 12 in. focus, and then is spread sideways by a dispersion lens which widens it into a sector subtending an angle of 22 deg. The direct rays of the arc are prevented from leaving the lantern by a carbon shield, but as the crater is turned toward the mirror there is very little loss from this cause. By the use of this apparatus the time of passing through the canal is reduced from an average of 36 hours to 15 or 18 hours. In the case of a vessel fitted with duplicate plant, the spare dynamo is employed to work the arc lamp in passing the canal. Vessels that are not fitted with electric appliances take them on deck on entering the canal and discharge them at the other end, and thus one set will serve a whole fleet of steamers.—*Engineering.*

IODIDE OF STARCH.

By H. B. STOCKS.

BESIDES the ordinary method of formation (*i. e.*, by adding a solution of iodine to starch paste), iodide of starch is gradually formed when dry starch and an alcoholic solution of iodine are triturated in a mortar, provided the alcohol contains water. With absolute alcohol a brown color is produced which, on the addition of water, changes to blue. It appears, therefore, that water is necessary to the formation of iodide of starch.

Iodide of starch is not formed when iodine vapor is passed over dry starch, but by using moist starch the iodide is formed. This also seems to show that water is necessary for the formation of this body.

It is formed by the action of various reagents on a mixture of potassium iodide and starch paste. The reagents are those which liberate iodine from its compounds—chlorine, bromine, nitric acid, strong sulphuric acid, ferric chloride, ozone (Schönbein), potassium permanganate, potassium bichromate, etc., produce the blue color.

The blue color produced by chlorine and by bromine is destroyed by excess of the reagents; excess of nitric acid or of sulphuric acid also destroys the compound.

In a paper by F. Mylius (*Ber.*, xx., 688, abstracted in *Journal Soc. Chem. Industry*) it is stated that the author has found that the formation of blue iodide of starch is not due to iodine alone, but also to the simultaneous action of hydriodic acid or an iodine salt. After reviewing the experiments that have been done, and repeating those of the author, I come to the conclusion that this is not the case. The statements made by Mylius are (1) that a solution of iodine in water does not give a blue color with starch; this is manifestly incorrect, because iodide of starch is formed under these circumstances. (2) That "all the iodine solutions which color starch blue contain hydriodic acid or an iodine salt." This may be answered in the same way, iodide of starch being formed when a solution of pure iodine is mixed with starch paste, or when iodine vapor is passed over moist starch. (3) "If a compound be present which destroys hydriodic acid—*e. g.*, chlorine—no blue iodine starch is formed."

With regard to this statement, Miller says that chlorine destroys iodide of starch, owing to the formation of chloride of iodine. This I think much more correct than the above.

The real fact is that a limited amount of chlorine, added to a mixture of hydriodic acid or an iodide and starch paste, colors it blue, owing to liberation of iodine, but excess of chlorine destroys the color. It may be that chlorine takes the place of iodine in the compound with starch, as a compound with bromine is known. (4) "A silver solution decolorizes iodine starch; on the addition of iodine, the mixture becomes yellow, but hydriodic acid or one of its salts restores the blue color." Repeating this experiment, it was found that, on adding silver nitrate to a solution of iodide of starch, the blue was destroyed, with formation of iodide of silver; on adding excess of iodine to this, the blue was reformed; if, however, without adding more iodine, hydriodic acid or one of its salts certainly produced a blue color; but this is simply explained when we take into account the action of nitric acid. I have not been able to find in books to which I have access what action iodine has on a solution of silver nitrate, but I believe that a portion of nitric acid is liberated, and this acts on hydriodic acid or its salt, liberating iodine, and thus we get the blue color.

I have stated the above in a concise manner, so as to show upon what grounds Mylius bases his idea that hydriodic acid or an iodine salt is necessary to the formation of iodide of starch.

Iodide of starch is soluble in a large quantity of pure water. As ordinarily prepared, it is an opaque blue mass, and when examined under the microscope is seen to consist of blue flocculent masses of the iodide floating in a liquid portion.

This shows that the idea of Liebig and others, that the color of iodide of starch was due to the starch granules being mechanically colored by iodine being deposited on their surface, was not correct, as in the above case the granules were entirely broken up.

On examining starch granules colored by iodine, it appeared as if the whole of the interior of each granule were colored. The iodine evidently has penetrated through the coating of starch cellulose into the inner portion, which consists of real starch.

The chief peculiarity of iodide of starch is the readiness with which the color is destroyed by heat. The change is gradual, the liquid becoming first greenish, then yellowish, and finally colorless. If, after boiling the iodide of starch until colorless, it be allowed to cool, the blue is not reformed. Pelletier states that the blue color is reformed on cooling, provided all the iodine has not been driven off by the boiling. If the heating is stopped at the yellowish stage, and the liquid allowed to cool, the blue is reformed to a slight extent, more so if only the greenish stage has been reached, but neither regain the original intensity of color, showing loss of iodine. During the heating the smell of iodine was noticed in the escaping vapor.

With regard to the decolorization of iodide of starch by heat, Baudrimont says that it is due to the volatilization of the iodine, and states that it does not occur in sealed tubes, when concentrated iodide of starch is used, or when the liquid contains excess of iodine. He also states that dilute iodide of starch, heated in a sealed tube thirty or forty times, was decolorized each time, and regained its blue color on cooling. Kraut states that iodide of starch becomes colorless when heated in a sealed tube for some hours.

It was found that a solution of iodide of starch, when heated in a sealed tube, became colorless in an hour, and did not regain its blue color on cooling; a solution containing much more iodine than the last required three days' heating before it was decolorized, and it remained colorless on cooling. It is evident, therefore, that when iodide of starch is decolorized by heat, iodine is not necessarily volatilized, as stated by Baudrimont, and that his solutions were not heated long enough, or they would have been decolorized. Langlois states the same, that a concentrated solution of iodide of starch was not decolorized on boiling. The same remark may be applied here, namely, that the solution was not heated long enough, or it would have become colorless, as a very strong solution I tried, though requiring much boiling, eventually became colorless.

The decolorized iodide still contains iodine in some form. It seems, then, that the iodine goes into combination as some colorless body, as no free iodine is present in the boiled solution. This is evidently the case, as blues containing much iodine take a longer time to decolorize than those only containing a small quantity, or, in other words, time is required for the decomposition of the iodide of starch and formation of the new body. This is stated to be hydriodic acid by Kraut; Pelletier and Fritzsche say it contains no free hydriodic acid; Langlois says it contains iodic acid. My experiments confirm those of Kraut. The starch is apparently not altered, for on adding more iodine to the decolorized liquid the blue was again formed, and this decolorization and recoloration may be continued a number of times without any effect upon the starch. In open vessels only part of the iodine is converted into hydriodic acid, the rest being volatilized; in sealed tubes, however, all the iodine is converted into hydriodic acid.

If we now refer to the trituration of an alcoholic solution of iodine with dry starch, we shall find that the iodide was not formed. This is mentioned by Pohl, who says that the alcohol overcomes the attraction of starch for iodine, but on adding water the iodide is formed, owing to its weakening the effect of the alcohol.

If absolute alcohol be added to a solution of iodide of starch, it is thrown out of solution, but the alcohol has no action upon it. I think, therefore, that the reason why iodide of starch was not formed in the above case is because of the absence of water, which seems to be necessary to its formation (see action of other reagents below).

With regard to the action of other reagents on iodide of starch, sunlight decolorizes it, as stated by Raspail, Guibort, and by Payen. A tube of iodide I exposed to diffused sunlight required about nine months to decolorize it. I expect the action of sunlight is similar to that of heat, only much slower, but have not yet examined the product, as my first tube was destroyed; however, I have another experiment in progress with a parallel tube kept in darkness.

Iodide of starch is precipitated from its solution by dilute hydrochloric, sulphuric, and nitric acids, strong hydrochloric acid, and by solutions of salts which do not act upon it, such as sodium chloride, barium chloride, etc.

Statch solutions are not precipitated by dilute acids, as the iodide is. Strong nitric acid and strong sulphuric acid decompose the iodide.

Acetic acid does not precipitate the blue compound.

The blue compound is destroyed by chlorine (Henry and Humbert), by bromine (as before stated), by sulphurous acid, by hydrosulphuric acid (Langlois), arsenious acid (Pisani), alkalies, etc. According to Pisani, the blue is destroyed by trichloride of antimony, chloride of arsenic, auric chloride, ferrous, manganous, mercurous, mercuric, and silver salts.

It is stated by Payen and Langlois that alcohol and ether abstract a part of the iodine from iodide of starch, but I did not find this to be the case, unless an excess of iodine is present, as a solution of iodide of starch treated with ether gave iodine up at first, but on repeated treatment with ether it still remained blue, but gave no iodine. A solution treated with alcohol gave up no iodine.

Starch has, therefore, more affinity for iodine than has alcohol or ether, or any other solvent for iodine I have yet tried. A solution of iodine in carbon bisulphide or benzine, when treated with starch paste, lost all its iodine, it combining with the starch; and oppositely, carbon bisulphide or benzine do not extract any iodine from iodide of starch, when it contains no excess of iodine.

Therefore I think we are justified in regarding iodide of starch as a compound, or probably more than one compound, of starch with iodine, water also being taken into account, and refer its decolorization by heat to the fact that the iodine contained in it is converted into hydriodic acid.

Many analyses have been made of iodide of starch and formulæ proposed, but as the figures are so widely different, it will be necessary to estimate the amount of iodine in iodide of starch prepared in different ways. I have not yet made any analyses of iodide of starch, but intend to do so if circumstances permit.

As the blue color produced by the action of iodine on starch is of an interesting nature, I may mention as a sequel the few other cases in which a blue color is produced by addition of iodine to organic substances.

1. A blue color is produced when iodine is added to a solution of Iceland moss or Carragheen moss. This is due to the substance called lichenin, which is similar to starch in its composition and properties.

2. By the action of sulphuric acid on cellulose a body is produced which is blued by iodine.

3. In a paper by Frank E. Lott (*Journ. Soc. Chem. Ind.*, 495, 1887), in a description of Fritz's butyl bacillus, he says: "The contents of the cells are partly colored by iodine of a violet approaching black, either the whole contents or single isolated patches of it (two or three) or sometimes only one spot. I might add that the reaction with iodine does not take place at all stages of the growth of this organism. It depends, also, to a great extent, on the nourishing medium."

It is most probable that in the last two cases it was really starch that gave the blue color.—*Chemical News.*

[Continued from SUPPLEMENT, No. 627, p. 10019.]

CHEMICAL AND ALLIED INDUSTRIES.*

By WATSON SMITH, Lecturer in Chemical Technology in the Victoria University, etc.

GROUP III.—DESTRUCTIVE DISTILLATION.

The Broxburn Oil Company, Limited, Royal Exchange Square, Glasgow (No. 750).—This firm exhibits specimens of the products obtained by the destructive distillation of Scottish boghead shale, together with samples of the raw material itself. It is an industry originally founded by the late Dr. James Young, F.R.S., about 30 years ago. Dr. Young commenced, however, not with boghead shale, but with the boghead cannel itself, a mineral the identity of which with cannel coal was disputed in a celebrated lawsuit started to upset Young's claims. This suit failed in its object, and so vigorously was the manufacture of paraffin oils, naphthas, and wax pushed, that the mineral became speedily exhausted. A fine specimen of this now extinct Scotch mineral, presented to the writer by the late Dr. James Young, is to be seen at stand 781. In the great lawsuit already referred to, the presence of a single characteristic coal fossil in the mineral would have quickly decided the case and have saved much expenditure of money, but no fossils were to be found in this boghead cannel. It is interesting, however, to mention that Professor W. Boyd Dawkins, when recently in Australia, identified a cannel which is practically identical with the old Scottish boghead, and fine specimens were brought over by him, and are now to be seen in the geological museum of the Owens College. The interesting point is that the Australian boghead *does* contain fossil remains. The first record we have of the manufacture of paraffin wax is that by a Manchester man (nevertheless a Scotchman), Mr. John Thom, of Birkacre (and of the firm of M'Naughton & Thom), who made it before the year 1835, by Reichenbach's process, from the products of the distillation of wood, as he informed the writer. He has still a specimen of the paraffin wax then actually put in the market. Mr. Thom was then the chemist in a works at Camlachie, near Glasgow. The present approximate annual production and value in the United Kingdom of the staple articles manufactured by the paraffin oil trade represented over £2,250,000. In the year 1886, to produce this value in the staple articles, there were consumed 1,816,600 tons of shale, and in the manufacturing processes there would be over 500,000 tons of coal consumed. The capital invested in the paraffin oil trade amounts to about £2,000,000. The articles exhibited by the Broxburn Company are: 1, crude oil; 2, sulphate of ammonia; 3, the refined products of the crude oil, which are burning oil in several qualities, naphtha of shale spirit, lubricating oil in various qualities, ordinary and debloomed; solid paraffin scale, the same in a refined state as wax of various qualities and candles prepared from it. The specimens of candles vary from the cheapest to the finest hand-painted kinds for drawing room use.

The Linlithgow Oil Company, Limited, Edinburgh, and 4 St. Ann's Square, Manchester (No. 748).—This is also one of the Scottish shale-distilling firms, and exhibits fine specimens of its raw and manufactured products, similar to those of the Broxburn Company.

The Dee Oil Company, 5 Cross Street, Manchester, and Saltney, Chester.—We now pass on to a handsome exhibit, illustrating the extraction of paraffin wax and paraffin products, not by destructive distillation from shale or cannel, but by direct distillation from crude American petroleum residues first deprived of their light naphtha in the States before export to this country. This is a special line of paraffin industry of itself, and the annual production and value in this country of the staple articles thus produced amount to about £150,000. For this an annual consumption of raw materials takes place represented by about £50,000.

The works of this firm are established just on the borders of Cheshire and Flintshire, at Saltney, near Chester, and the history of the oil trade in the locality of North Wales is one of peculiar interest. The trade may be said to have had its origin in the discovery of "curley cannel" coal in Flintshire, on the borders of Cheshire, about 26 years ago. This discovery led to the establishment of many companies and works in Flintshire for the production of paraffin oil, and the new industry was commenced with great vigor. However, American petroleum also came to the front, and the competition became too severe for the Flintshire paraffin industry. Burning oil reaches this country from the United States far cheaper than it could be made here from English products. At the present moment there is not a single firm in North Wales producing oils from the curley cannel of the district, which moreover is nearly exhausted. During the decadence in this locality of the cannel paraffin industry, one of the last of the surviving companies—viz., the Coppa Oil Company, who amalgamated with the Dee Mineral Oil Company, which then assumed the title of the Dee Oil Company, under which title it trades at the present time. There is a lesson for chemical manufacturers in this little history, one which as to facts has been repeated and will be repeated scores of times. It is this: In times of change, depression, and revolution of circumstances, only those can survive and continue to flourish who possess elasticity and energetic mental and physical vigor, backed up by and supported with scientific knowledge and intelligent observation. It is clear that the Dee Oil Company possessed these qualities, and the subsequent history of the firm shows that they were thoroughly needed. Thus, somewhat later, it was found that the paraffin scale and crude wax market became glutted, and no competition could be longer undertaken in that direction. The Dee Company therefore utilized the apparently hard circumstances by at once erecting its only candle works, where it could manufacture its own raw material into candles and so remove it beyond the region of impracticability and danger. To cut down other expenses the company further erected its own sulphuric acid works, and will shortly put up its own stearin plant. Competition was thus fought with its own weapons. The samples of manufacture exhibited comprise specimens of crude petroleum as taken from the American wells, refined petroleum, burning oils and residuum, which, as has been stated, is the material used by this firm. From it are manufactured lubricating oils of different brands, cylinder oils, and a special class of oils termed "valvolines" sterling. They are oils for internal lubrication, and are said to be superior to even the best makes of cylinder oils. They are especially recommended for use with sight feed lubricators and in all high pressure steam cylinders. They are remarkable for a high flash point (510° to 550° F.), a low setting point (under 32° F.), and a great viscosity, even when exposed to high temperatures. An entirely new method is used for their preparation, avoiding, it is said, distillation and treatment with acids and alkalies. Three grades are exhibited—"torpedo oil," for use on torpedo boats, launches, etc.; "dynamo oil," adapted for electric machines; "gas engine" and "ring spindle" oils. We observe also a preparation for therapeutic use, *oleum Deelinæ*, a medicinal oil for skin diseases. Besides these we see many other varieties of oils, and also fine specimens of paraffin wax, and candles, both plain white and colored.

Messrs. Ragosine & Co., 7 Idol Lane, Great Tower Street, London, E. C. (No. 783).—This exhibit is one illustrative of the advanced present position of the Russian petroleum industry. Two of the most wonderful things in connection with this industry are its apparently inexhaustible stores of natural raw material in the neighborhood of Baku, South Russia, and the enormous rapidity with which that industry has developed. To give an idea of this advance and development, it may be interesting to sketch the history of the firm whose beautiful exhibit is under consideration—that of Ragosine & Co.

In 1876, when the monopoly in petroleum at Baku was abolished by the Russian government, the production began at once to increase enormously, but so far the only valuable products obtained from the crude oil were spirit and burning oil. Since the Russian crude oil only yields 27 to 30 per cent. of these, there remained an enormous production of residuum, which was for a long time used as fuel or entirely wasted. It was Victor Ivanovitch Ragosine who first suggested the utilization of the heavier portions of the crude oil for the manufacture of machinery oils and greases. The firm of V. I. Ragosine & Co. was founded by him in 1876, at Nijni Novgorod, with a capital of 200,000 rubles. A refinery was built at Balachna, on the Volga, in 1876, and a second at Constantinow, in 1880. The capital of the company was raised by successive fresh issues to 3½ million rubles, and in 1880 this company obtained an imperial charter. The works at Balachna and Constantinow are supplied with raw material from Baku, by a system of tank barges, which are towed up the river during the month of May. The two refineries together have storage in iron tanks (each of about 2,500 tons capacity) of upward of 30,000 tons of crude oil and residuum. The plant at the two works includes 54 stills, and is capable of treating 35,000 to 40,000 tons of crude oil per annum, and of producing from 30,000 to 35,000 tons of lubricating oil, etc. The oils made from the Russian petroleum were first introduced into England in 1878. No mineral oils of the same "body" it is said, have been seen before, and this "body," or better "viscosity," of the Russian mineral lubricating oils indicates their special advantage. The viscosity of Russian oil of specific gravity 0·915 is about six times that of American oil of the same specific gravity at 60° F. The viscosity diminishes rapidly as the temperature rises, but even at 120° F. the Russian oil is claimed to possess three times that of the American of the same specific gravity. As compared with colza and olive oils, the Russian of 0·905 specific gravity has roughly about two or three times the viscosity at 60°; at 120° F. they are about equal. These statements are confirmed by the tables of William McIvor and Boverton Redwood. Hence (1) high viscosity—*i. e.*, lubricating power; (2) freedom from acid; (3) absolute immunity from "gumming," since oxidation and drying cannot take place; (4) very low freezing point. The Russian crude oil contains practically no paraffin. A valuable product, viz., paraffin wax, is lost by this peculiarity, but the cost of freezing out the scale from the lubricating oil is saved. The burning oils, "petroleum" of specific gravity 0·826, No. 3, now largely used in this country and said to have a higher flash point than the corresponding American product, and equal illumination, "pyronaphtha" and "australine," special oils of very high flash point, viz., 200° and 130°, and used in specially constructed lamps, are pressing the American oils very hard. When the inert residuum of the American petroleum is destructively treated in red hot tubes, a large amount of charring takes place, and very little—scarcely any—increase of value in the distillate occurs, but if Russian petroleum residues are similarly treated, as was first discovered by Letny, and Liebermann and Burg, of Berlin, these residues are converted, it is true with much charring, into the true coal tar products, benzene, toluene, naphthalene, anthracene, etc.

Besides a fine collection of crude petroleum, with naphthas, lubricating and burning oils of all kinds, as well as oils for other special uses, a set of interesting specimens of aromatic hydrocarbons, such as are obtained from gas tar by the tar distiller, and used in the making of aniline and other coal tar dyes, is exhibited. Those specially interested, on proceeding to Stand No. 781, may see there a specimen of crude anthracene obtained from the Russian petroleum in the way specified, and another of 20 per cent. alizarin prepared from the anthracene, and finally a piece of printed and dyed cotton, in the coloring of which some of this alizarin was used. It has been, however, sufficiently proved by numerous practical experiments that the method of preparing coal tar hydrocarbons by carbonizing the petroleum or residuum will not pay, and we believe the process is now entirely or almost entirely abandoned.

J. C. & J. Field, Upper Lambeth Marsh, London (No. 732).—This firm, though also manufacturing and exhibiting a special kind of soap, is best known for its "ozokerite" candles, ozokerite being a peculiar mineral wax occurring largely in Galicia, and containing a very considerable proportion of paraffin. It is thus a kindred substance with crude petroleum. Ozokerite was probably formed by the denuding action of water on peaty and similar vegetable remains, the vegetable part being gradually removed and the insoluble resins washed away or deposited. Till about 1770 wax and tallow were the sole ingredients of candles. The wax candles were "rolled," the tallow "dipped" or "moulded." The wicks in all cases were of twisted cotton, except in the cheaper tallow candles, in which rushes, partly stripped, were used. In 1850, James Young having isolated paraffin, J. K. Field took out a patent for manufacturing candles therefrom, which at once became very popular. Subsequently various members of the Field firm patented different forms of the candle—spiral, cable, etc.—to which the plastic and transparant paraffin readily lent itself. In 1872 the attention of F. Field, F.R.S., was drawn to the mineral wax ozokerite, long known in Galicia. In 1874 a patent was taken out for the distillation of the crude earth wax, and the white, very hard paraffin now known as ozokerite was produced (melting point 142° F.).

The recent introduction of semi-refined paraffin scale into the candle trade has almost annihilated the composite and tallow candle branch of the industry. The amount of candles and night lights produced in Great Britain annually cannot be much under 30,000 tons, probably it exceeds this estimate. Price's Company turn out over 60,000,000 night lights annually. The amount of palm oil imported into England exceeds 40,000 tons, tallow (exclusive of home consumption) 20,000 tons. (See Field's Cantor Lectures, *Journ. Soc. Arts*, 1884, and Rep. on Oils and Fats, C.I.E., 1886.) The principal part of Messrs. Field's exhibit, the "samphire soap," is an article made by Dr. Alder Wright's ammonia process, and in this process all free alkali is removed. Moreover, a small quantity of free iodine is introduced, and glycerin of specific gravity 1·26 is substituted for the 20 per cent. of water usually present in toilet soaps. Eucalyptol, the essence of the *Eucalyptus globulus*, in an iodized and semi-saponified form, is finally added.

Price's Patent Candle Company, Limited, Belmont Works, Battersea, London, S. W.—This exhibit is one made by a firm which has a remarkable history. It is owing to a discovery made by a member of this firm that cheap and pure glycerin may now be had in abundance. To describe the development of the firm in detail would be out of the question, for, to begin with, more than eighty patents have been held by Price's Company. The great French chemist Chevreul, now over a hundred years of age, but still active as a chemist, in 1811 began his researches on the constitution of fats and oils, and in 1823 he completely published his discoveries in this direction. In conjunction with Gay Lussac, he attempted the industrial application of the scientific principles he had made known, but did not attain the success he doubtless anticipated. It was reserved to M. De Milly to lay the foundation of the stearic candle manufacture in 1832. In 1833 the "Bougies de l'Etoile," as the candles of MM. De Milly and Motard were called, were sold in Paris at about 1s. 8½d. per pound (retail), and at this price were placed on the market to the extent of about 25 tons per annum. In 1829 Mr. James Soames, of London, separated cocoanut oil into its solid and liquid components by pressure. He took out a patent for it. The patent was purchased by Mr. William Wilson and his partner, who worked under the title of "E. Price & Co." They perfected it, and produced by its aid cocoanut candles and lamp oil. In 1847 the concern passed into the hands of "Price's Patent Candle Company," Mr. William Wilson becoming the first chairman, and his two sons—J. P. Wilson and G. F. Wilson—the managing directors. The plated wick, patented in France in 1825 by Cambaceres, was introduced in England by Henri Meyer, subsequently manufactured near Derby by Mr. Thomas Topham, and he in 1836 was supplying the wick to E. Price & Co. In the year 1840 Mr. J. P. Wilson, while endeavoring to produce a cheap self-snuffing candle for the coming illumination in honor of the marriage of Her Majesty Queen Victoria, then approaching, succeeded in making such candles of a mixture of equal parts of stearic acid and cocoanut stearin. They gave a brilliant light, required no snuffing, and could be sold retail at 1s. per lb. The new candles came rapidly into notice, and the sales advanced in a manner entirely without precedent. They were termed "composite," because of the mixture of materials in them. Such was a new and successful departure in illumination for our homes and on festive occasions at the date of the marriage of Queen Victoria.

In 1840 George Gwynne took out a patent for the distillation of the fatty acids *in vacuo*. It is these fat acids which, chemically united with glycerin, form true fats, much as sulphuric acid united with soda forms a salt, sulphate of soda. The knowledge which had already been acquired that these fat acids could be distilled without destruction or decomposition was thus for the first time commercially applied. But in 1842–43 Messrs. Price & Co., in the names of W. C. Jones and G. F. Wilson, patented a still more important discovery, superseding the first. They discovered that all the good effects of the vacuum process could be gained by substituting the use of free steam. Thus the costly vacuum still was avoided. With respect to the hardening of fats, Fremy, another great French chemist, had shown in 1836 that treatment with 50 per cent. of their weight of sulphuric acid in the cold was needful. In commerce this was impracticable. Clarke and Gwynne patented a process based on the foregoing in 1840, but Jones and Wilson subsequently proved that if the mixture were warmed, not cooled, then 33 per cent. of sulphuric acid would suffice, and still all the good results be obtained that were realized in the other process. Another commercial success was the result.

In 1848 the night light patent of G. M. Clarke, and in 1849 the night light business of S. Childs were acquired, a new factory was erected, and in 1852 the sale of night lights already amounted to over twelve millions per annum. Some years before the English mill owners could be induced to use oleic acid instead of olive and other oils for the oiling of wool, that acid, as produced in large quantity in the manufacture of stearic or hard candles, had been thus successfully used on the Continent. The

* Report on Section III. of the Manchester Royal Jubilee Exhibition.

process of Messrs. Price & Co., by distillation, appeared likely to remove the impediment in this country, and so in 1851 the English patent of Messrs. Alcan and Peligot (another noted French chemist) was secured for the use of oleic acid as a "cloth oil." However, it was only after some time the prejudice of the Yorkshire millowners was overcome. In 1854 R. A. Tilghman took out his English patent for acidifying fats and separating them into fat acids and glycerin by means of contact with water under high temperatures and pressures. The company took an exclusive license under this patent. However, a still further and very material advance was made when Messrs. G. F. Wilson and G. Payne, in 1855, discovered that netural fats could be broken up (a kind of partially destructive distillation or, better, analytic distillation or hydrolysis) by distillation with superheated steam alone. Before the close of this same year Mr. G. F. Wilson secured another discovery and patent for his firm of great commercial importance and scientific interest. He found, namely, that glycerin could be distilled without decomposition by the use of steam. Previous to this date a chemically pure glycerin had never been seen.

Under the new patent such a product became not only possible, but commercially so. In 1850 James Young obtained his celebrated patent for the production of paraffin hydrocarbons by the destructive distillation of coal at a low red heat. In 1853, seeing the progress of Mr. Young's paraffin industry, Mr. Warren de la Rue took out patents for working the Burmese or Rangoon petroleum. Hardly had the first exports of some 10,600 gallons of burning oil prepared from this Rangoon petroleum to New York in 1859 been effected when "oil was struck" in America, and this new discovery of petroleum upset all calculations as to the value of the Rangoon article. Meanwhile Messrs. Price & Co. turned their attention to the perfection of the candle and other machinery. The increased use of American burning oil had no slight effect on the company's sales, for whereas in the five years 1857 to 1861 46,905 tons were got rid of, in 1862 to 1866 only sales of 43,609 tons were effected.

The firm now carried the war into the enemy's camp, and from using paraffin scale from Scotland and the United States a forward movement was made, first in the patenting a new process for producing fine white paraffin wax without the use of the dangerous spirit generally used in the washing processes, and secondly in enlarging and improving its paraffin refinery at Battersea. At the present time, it is said, Price's Company is the largest refiner of paraffin in the world. By this indomitable perseverance and intelligent co-operation with circumstances the falling off already referred to in the transition period was soon recovered, the previous highest sales surpassed, and in the five years 1882 to 1886 the salable produce rose to 80,205 tons. At present the approximate annual production of the articles manufactured by Price & Co. is 18,000 tons; value about £700,000. The annual consumption of raw materials is about 19,000 tons. The present annual production of paraffin candles in this country is 27,000 tons, of stearin candles 7,500 tons.

After what has been recorded of the invention of a new and brilliantly burning candle, just in time for household use and for purposes of festive illumination about the period of Her Majesty's marriage, it would seem natural that some special memento might be afforded of such an occasion in the exhibition. This has been the case, for Messrs. Price exhibit a life size bust of Her Majesty in pure white stearic acid, standing on a pedestal of the same fat acid, supported on a cube of the material used in the manufacture of the gold medal palmitin candles. The soaps exhibited by this firm are extremely varied, and are of excellent quality. An interesting exhibit of candles, night lights, tapers, etc., and the machinery used in forming them, is to be seen in the machinery annex, stand No. 416.

I. Levinstein & Co., Manchester (No. 742).—There is here a model of its kind, for it is both eminently beautiful as well as instructive. Very artistic, too, is the arrangement of the little pavilion, which forms the show stand. For if the visitor go inside it he at once loses sight of any specimen of dye, color, or other material used in the preparation and coloring of the exquisite ornamental silks, wools, and flowers, which are so arranged as to make the interior resemble that of a conservatory. Let him proceed to the outside, and immediately on passing the doorway he at once loses sight of the ornamental and artistic enbellishments, and a series of elegantly arranged chemical specimens presents itself. He may now see and examine all the materials and products through every stage, from the raw coal to the finished dye and coloring matter, as well as other useful coal tar products.

But Mr. Levinstein has so devised it that not only are the specimens and samples shown, but they are exhibited in the proportions in which they are practically obtained in the factories, so that, commencing with the cubical block of coal weighing 1 cwt., the specimens shown in the lower compartments of the pavilion represent also the proportions by weight obtainable from the 1 cwt. of coal aforesaid. We observe on the 1 cwt. block of coal a small bottle containing saccharine from coal tar, the announcement of the manufacture for the first time of which was made by Mr. Levinstein nearly two years ago. The little sample in question represents the actual proportion obtainable from the large block of coal on which it rests. Besides the raw and intermediate products, which are shown in all completeness of detail, about 100 different coal tar dyes are also exhibited. As regards illustrations of dyeing power as exhibited in the superficies of fabric which can be dyed to a full shade, the 1 cwt. of coal already mentioned is here again brought usefully into requisition, and around the block are arranged some folds of flannel dyed scarlet, and representing accurately, therefore, the amount of scarlet dyeing power (if it may be so described) that resides in the 1 cwt. of coal. Especially we notice fine specimens of the eosines, naphthol yellow, and azo scarlets for which this firm has obtained such celebrity.

Messrs. Josiah Hardman & Co., Miles Platting, Manchester (No. 747).—An accurate and beautifully constructed model of the tar distillery in its most complete form first strikes the eye of the visitor. This model is, moreover, no fanciful representation, and to show how thoroughly its arrangement and planning have been thought out and designed, it is modeled to scale, and on its premises are arranged sulphuric acid chambers, with all the paraphernalia of a vitriol works, so necessary an adjunct in these days of low prices, when materials must be as far as possible manufactured direct rather than bought. As regards the splendid collection of specimens, these are arranged so as to exhibit not only quality, but also proportion, by weight derived from a given unit weight of raw coal. A large cubical block of coal is shown and the weights of useful products derived also, and, further, the quantities of different fabrics that can be dyed with the given proportions of colors that may be extracted from the block are exhibited. This furnishes an interesting and striking idea of measurement of the coloring capacity that is latent in ordinary gas coal. The exhibit of course includes crude as well as purified products obtained from coal tar, ammoniacal liquor, and spent oxide.

Messrs. Hardman & Holdens, Miles Platting, Manchester (No. 746).—A kind of branch firm of the foregoing. Here is seen a most attractive and interesting exhibit arranged to illustrate the manufacture of alizarin from coal tar, and showing a series of chemical products with their derivatives, remarkable for their purity and beauty. The practical application of alizarin to cotton is shown by a variety of dyed and printed yarn, cloth, velvet, etc. Alizarin colors on fabrics are also shown alone as well as in conjunction with other dyes.

Special prominence is given to the exhibition of specimens illustrating the advances made in the dyeing of silk and wool with alizarin. Skeins of silk in six colors, showing four shades of each, also examples of dyed and printed silks, form a new and pleasing feature in the exhibit. Moreover, samples of wool in various shades, also cloths and tweeds in which alizarin-dyed wool predominates, are shown. The old original madder in various forms is not forgotten, and some specimens of madder dyed and printed fabrics are exhibited, among the most interesting being the Indian dresses, woven and dyed with munjeet (*Rubia munjista*) by the natives.

It was not until the expiration of the German patents that Hardman & Holdens, who were first in the field, were able to start their alizarin work. There are now three English makers, and it seems probable that ere long England will make all the alizarin she consumes. One effect of this competition following the expiration of the patents has been that whereas four years ago the price of alizarin was 2s. 6d. per lb., the present market price is only 8½d. per lb.

Messrs. Sadler & Co., Limited, Cleveland Chemical Works, Middlesbrough (No. 744).—This firm makes a specially interesting exhibit of coal tar products, crude and refined, and among the latter notably alizarin, aniline, and other coal tar dyes; likewise acids, alkalies, and other chemicals are represented as being manufactured for use or in order to the working up of by-products. It is worthy of mention that Messrs. Sadler & Co. were the first manufacturing chemists to recognize the practical value of the coal tar from the coke ovens on the Simon-Carves system as worked by Messrs. Pease & Partners, at Crook, near Darlington; and long before other manufacturers were willing to admit the genuine character of that tar and ammoniacal water, or thought anything about the subject, this firm had made contracts for both products and worked them to profit: and hence Messrs. Sadler & Co. were certainly the first firm, at all events in this country, to make alizarin and other coal tar coloring matters from coke oven tar. As a record of enterprise, the foregoing may be placed at the head of the brief list now to follow. Alizarin is one of the specialties of this firm, and in its manufacture Messrs. Sadler enjoy the advantage not only of making the raw material, anthracene, direct from coal tar, but they make at the same time all the other chemicals which are necessary for its complete production.

By their process they produce an article of exceptional purity. The beautiful dyed and printed specimens illustrating the effect of Messrs. Sadler & Co.'s alizarin and allied colors on the fiber were furnished, we understand, by Messrs. E. Potter & Co., of Dinting Vale. With regard to aniline colors Messrs. Sadler & Co. commence with the tar, distill it, and proceed onward to the finished colors. Their magenta is produced by the nitro-benzene process. Another dyestuff, viz., Bismarck brown, is made by a patent process direct from dinitro-benzene, the benzene for this being extracted from coal gas.

This firm manufactures oxalic acid largely from sawdust. Among the alkali products, soda is made from salt, which occurs largely in the strata below the ground on which the factory stands, and the sulphuric acid from pyrites obtained from the Cleveland hills in the neighborhood. Fuming sulphuric acid, considerably used by the dye manufacturer, Messrs. Sadler make from bisulphate of soda.

Epsom salts, for a great number of years made in Middlesbrough from the magnesian limestone, are now entirely manufactured from kieserite, a refuse product of the Stassfurth mines.

All the waste products of the factory which possess any value for the purpose are mixed with dissolved bones and superphosphate, which is also made in large quantities and sold in the form of manures.

The British Alizarin Company, Limited, Silvertown, London, E. (No. 736).—This beautiful exhibit, mainly a reproduction of the one which excited so much admiration in the late international inventions exhibition, and which gained a gold medal there, is not only of present interest, but it illustrates well the history of the development of the madder and alizarin industries.

1st. Is a series of specimens illustrating the growth and form of the madder plant and various dyeing products derived from it. These natural dyes have been superseded by the "alizarins." Specimens are also shown of cotton prints prepared with madder colors.

2d. There are specimens showing the crude products from the distillation of coal tar.

3d. Specimens illustrating the process of the manufacture of alizarin, flavopurpurin, and anthrapurpurin from crude anthracene, together with others exhibiting some of the chemical properties of anthracene and its derivatives, as well as further specimens of the pure chemical substances which occur along with pure anthracene in crude coal tar anthracene.

4th. Numerous specimens of printed and dyed cottons, muslins, velvets, cretonnes, etc.; also others of dyed turkey red cloths and yarns produced with the alizarin colors of the British Alizarin Company, Limited. Some of these specimens show the alizarin in conjunction with other coloring matters.

5th. According to an instructive system of arrangement, a series of samples illustrating the various stages of cotton printing and dyeing with alizarin is shown—*e. g.*, cotton cloth in all the following conditions and in the following order: Gray, bleached, mordanted, fixed, dyed, oiled, steamed, cleared, and finally finished.

6th. Specimens exhibiting the shades obtained by the same mordant from alizarin, anthrapurpurin, and flavopurpurin respectively.

7th. A "five-striped swatch" (mordanted and dyed cotton cloth), showing the colors produced by various mordants from the same alizarin dye bath. Besides the foregoing are two Indian figures, draped in native costume, printed with alizarin, and numerous samples of wool and silk dyed with the same coloring matter.

Messrs. Brooke, Simpson & Spiller, Limited, Hackney Wick, London, E.; also 106 Portland Street, Manchester (No. 732).—This firm is one which has a history, for in earlier days, under the style of Simpson, Maule & Nicholson, it acquired a European reputation for violet and blue dyestuffs. The magentas and acid magentas produced by Messrs. Brooke, Simpson & Spiller have a reputation for exceeding purity and beauty of color. Dyed and printed patterns indicate the applications of the dyestuffs exhibited.

Society of Chemical Industry of Basle, Switzerland, formerly Messrs. Bindschedler & Busch (No. 743).—W. G. Thompson & Co., Cooper Street; and O. Isler & Co., Marsden Street, Manchester.—The writer has had the privilege of inspecting the works, laboratories, and offices of this, the foremost of Swiss color and dye manufactories, comprising aniline and azo color factories, and also an extensive alizarin works. The laboratories are extensive, excellently arranged, and form a leading feature of the establishment. They are manned by a staff of 15 chemists. Throughout the works, cleanliness and good order are qualities which at once strike the visitor. Excellent discipline is also everywhere observable. There are from 350 to 400 workmen and foremen. To give an idea of the steam power required in a factory of this kind, we may mention that 11 steam boilers, representing in the aggregate 1,100 horse power, are regularly at work. No less than 22 steam engines are in operation for the communication of power. The specialties quoted by this firm from a long and well classified list of their products are the following: Violet 5 B crystals, ethyl purple, Victoria blue B and 4 R, night blue, auramine, tartrazine, acid magenta, fast green 3 B, crystals acid violet 7 B, alkali violet.

St. Denis Dyestuff and Chemical Company, Limited (Poirrier & Co.), St. Denis, Paris, and 3 Booth Street, Manchester (No. 740).—This exhibit is well worthy of the foremost firm in France in the manufacture of dyestuffs. Among the coloring matters shown, we observe some interesting ones of the azo class, and not the least so that one termed "roccelline."

Manchester Aniline Company (Charles Truby & Co.), 55 High street, Manchester, and Clifton Junction (No. 738).—This exhibit comprises specimens of aniline oil for dyeing, calico printing, and color making, of essence of mirbane (nitro-benzene) for scenting soap, dinitro-benzene and toluene, pure naphthalene, nitronaphthalene, arseniates of soda, oleine as alizarin oil, soluble oil, and all the special materials for sizers and finishers.

Von Hohenhausen & Co., Yew Tree Chemical Works, 303 Collyhurst Road, Manchester (No. 745).—An elegant display of all the materials used by the calico printer and dyer which come under the headings of mordants, dung substitutes, preparing liquors, assistants, etc., together with some special dyestuffs. The sulphocyanides and acetate of chrome deserve special mention.

Dan Dawson Brothers, Milne Bridge Chemical Works, Huddersfield (No. 737), exhibit a neatly arranged series of specimens illustrating the chemicals and coal tar dyes manufactured by them.

Charles Lowe & Co., Reddish, near Stockport, and Piccadilly, Manchester (No. 739).—With the name of Charles Lowe that of chemically pure carbolic acid is intimately associated. Mr. Lowe was the discoverer of a finely crystalline hydrate of carbolic acid, and the name of his firm has for long been taken as a guarantee of excellence and purity of manufacture of the carbolic acid preparations and derivatives—some of them dyestuffs—which are manufactured there. A novel method of exhibiting the phenol and other colors in a kind of glass case is adopted.

J. C. Siegerist, 41 Faulkner Street, Manchester (No. 731), representative of the Fabriques des Produits Chimiques de Thann et de Mulhouse, Alsace.—In the first place are exhibited colors in dry, paste, and liquid states, specially prepared for calico printing. These colors are, almost without exception, "finished colors;" that is to say, specially prepared colors, which, in order to be printed upon the cloth, simply require mixing with a thickening such as starch, gums, albumen, etc., according to the nature of the color. No mordants having to be added to these colors by the printers, the latter are easier for them to manipulate, and are said to give more satisfactory results as to uniformity of shade, etc., than colors made up by themselves. There are colors for ordinary calico printing, indigo discharge, and others for printing on alizarin red dyed cloth. The principal feature in the latter (both blues) is that they are simply printed on the cloth with a thickening, steamed, and then washed. This gives a very good imitation of indigo discharge on turkey red.

There is also one color (Alsace green) for piece dyeing, and this color can be discharged. With the exception of a few, these colors are said to be fast to light and soap. We observe (2) colors for printed wall papers; (3) colors for wool dyeing. Among these is an aniline blue which gives shades equal to indigo. The color is even faster than indigo both to light and soap, and no acid can discharge it. It stands milling and felting perfectly well. (4) Chemicals used as mordants, etc.; (5) substances used in the making of aniline colors; (6) chemicals for producing blacks on cotton goods; (7) aniline colors for wool, silk, and cotton; (8) glycerins made from pure stearin; (9) albumens; (10) Senegal gums.

B. Kuhn, agent for L. Durand and Huguenin, Basle, Switzerland, 55 Bloom Street, Manchester, and 36 St. Mary at Hill, London, E. C.—An interesting display of coal tar colors is shown for dyeing and printing wool, cotton, silk, etc., with patterns to illustrate the shades and character of these colors. Special dyes for leather

are also exhibited, with specimens of that material dyed and printed. An interesting feature of the exhibit is, however, the new coal tar medicaments shown. First we observe "*salol*," or phenyl salicylate, which has been recently applied with success as an anti-rheumatic. It is better to take than salicylic acid, which deranges the stomach. The salicylic acid of the salicylate (salol), however, is, after all, the effective agent, but the decomposition necessary to set free that acid from its combination with the phenol only takes place when the dose of salol reaches the duodenum, and consequently only after it has passed through the stomach. "*Antifebrine*" is the second therapeutic agent exhibited; its true name is *acetanilide*. The therapeutic name indicates its use.

(*To be continued.*)

MEASURING DEFINITE QUANTITIES.

H. TRESKOW.

THE construction of this apparatus, which is made of glass, will be readily understood from the accompanying diagram. *a* is the vessel containing the nutritive solution, *b* a graduated cylinder, *c* a cock with a right angled aperture drilled in it so that there may be either

a passage from *b* to *a* or from *b* to *d*, which is the outlet tube. *a* and *b* are preferably closed by plugs of cotton wool. Any desired quantity of the solution can thus be rapidly measured into a test tube without any risk of introducing micro-organisms, as would be the case if a pipette were used.

A NEW EXTRACTOR.

DR. R. REMPEL.

THE author, finding Soxhlet's and Drechsel's apparatus unsatisfactory for the purposes for which he required them, has devised an extractor which may be made of size sufficient to treat 100 grms. or more of material at one operation. In the subjoined figure, A is the extractor with a lower bulb, H. It is connected by corks with an upright condenser, C, above, and with a flask, B, to contain the solvent beneath. Within A, and maintained in place by an air-tight cork on which it rests, is the tube, D, which has openings, F, above into A, and also openings into the bulb, H, of the extractor; through the cork is passed the tube, E. This innermost tube is cut off at an angle beneath and has

a notch, G, at the top of the longest side. The mouth of the condenser is closed by a plug of cotton wool. When in use, the bulb, H, is filled with cotton wool or other filtering medium, and the matter to be treated is placed above.

The vapor of the solvent passes from B through the tube, E, and the holes, F, into the extractor, A, and thence into the condenser, where it becomes liquefied. The liquid percolating through the substance under extraction becomes more or less saturated and finds its way through the lower perforations in D; and as more liquid condenses, it gradually rises between the two tubes until the notch, G, is reached, when it finally trickles down the walls of the tube, E, into the flask. The height of the solution in the extractor may be regulated by adjusting the sliding tube, E; or, if the material treated permits only a very slow filtration, this tube may even be removed without fear. The extraction ended, the vessel, A, is emptied, the tube, E, then raised as high as possible and the liquid still left in B distilled into A, whence it is subsequently removed. The greater part of the solvent is thus recovered without the aid of any special distilling arrangement.

LABORATORY APPARATUS FOR FRACTIONAL DISTILLATION.

P. MONNET.

THE tube, D, which serves as the dephlegmator, is 0·35-0·4 m. high and has an internal diameter of 28-35 mm., narrowed to 5 mm. at the bottom to allow of its being fitted into the stopper of the flask, B. It is filled with lead shot or, if acids are distilled, with pieces of

glass or flint. For ordinary use lead shot No. 4 is used for the lower half and No. 6 for the upper half, the two being separated by a piece of copper gauze. In the case of very volatile substances, finer shot is employed and the length of the tube increased. A funnel with an upturned edge is inserted above the narrowed portion of the tube to support the shot. I is the tubulure leading to the condenser and H the thermometer which is fixed just above the top of the lead shot.

300 c. c. of a mixture of equal parts of water and alcohol yielded the greater part of the alcohol, on distilling, of a strength of 95 per cent., and with a mixture of aniline and toluidine the author obtained nearly two-thirds of the aniline in a pure state after three distillations.

APPARATUS FOR FRACTIONAL DISTILLATION UNDER REDUCED PRESSURE.

L. MEYER, Berlin.

THE vessel, A, is attached to the end of the condenser, B. In the upper end of A, which is 16 mm. wide, a glass tube is fitted through a cork. The lower end of this tube is cut off at an angle, and is well ground into the narrow part of A at *a*. Below *a*, the lower end of A again widens and is then drawn out conically and cut off at an angle. To this conical piece the receiver, D, is attached by a well fitting cork. The tube, C, is bent above A at right angles, and on the horizontal portion a three-way glass cock, *c*, is fitted. A similar cock, *b*, is attached to the side of A. A simple tap may be substituted for the latter; a three-way tap is preferable in case the liquid should froth over. In order to use the apparatus, the two taps, *b* and *c*, are attached by strong narrow India rubber tubing (1-2 mm. inside diameter, 3-4 mm. thick) to a T piece, E, and this is connected with a manometer and water jet aspirator. It is convenient, in case the liquid should run back, to

insert a large empty wash bottle between E and the pump.

The tube, C, is raised by a gentle upward turn, so that A and D are in connection, and both taps turned, as in the figure, so that both are in connection with the pump. If a fraction of the distillate is to be separated, the tube, C, is pressed down, which shuts off D from A. In order to remove D, the tap, *c*, is so turned that air enters through the tail of the tap and enters D through C. When D has been emptied or filled, *c* is slowly turned through 90°, so that it is again in connection with the pump. The small quantity of air introduced produces a very slight change of pressure. When D has been again evacuated, by raising *c* the liquid in A is allowed to flow into D. The author recommends cork and not India rubber stoppers.

ROBERT KOCH—HIS WORK AND METHODS.

By GEO. W. LEWIS, JR., A.M., M.D., Buffalo, N. Y.

TEN years ago, Dr. Robert Koch was living in comparative obscurity in one of the small towns of Germany, engaged in a work the nature of which attracted the attention of only a few widely separated scientists. It was at a time when little or no reliance was placed in the feebly supported germ theory of disease, and the few outbursts of evidence which tended to establish its truth were so much at variance with each other and with popular prejudice that but little headway was made. In a modest way he gave utterance to the results of his experiments, but his opinions passed comparatively unheeded until he demonstrated the so-called tubercle bacillus before a poorly attended meeting of scientists which convened in the city of Berlin. This served to arouse public interest, both in the man and in the subject upon which he had thrown a new light. During the following year his views were confirmed by other prominent workers in the field of bacteriology, and the tubercle organism soon came to be regarded as a reliable factor in the diagnosis of this disease.

He had outgrown the little town that fostered his early discoveries, and now felt the need of greater facilities for research and intercourse with the scientific world. He therefore located in Berlin, and shortly after became identified with the Imperial German Board of Health. Asiatic cholera next attracted his attention, and he spent the three following years in different parts of India, where the disease is epidemic most of the time. Together with a corps of worthy assistants, he visited every locality that seemed to favor its spread, with a view of ascertaining, if possible, the origin of the infectious material. Although he found that cholera was rife most of the year in Ceylon, Madras, and Bombay, he was able to trace its transmission to these places to the active traffic between them and certain parts of the delta of the Ganges. Further research satisfied him that this latter tract was the home of the disease, and his reasons for thus closely confining its habitat were based on the general character of the region.

The upper part of the delta is densly inhabited, while the lower part or base of the triangle, which lies at a considerably lower level, is unapproachable to man on account of the inundations and the pernicious fevers which invariably attack any one who passes its borders. In this uninhabited part he found a luxuriant vegetation and an abundant variety of animal life. The products here exposed to putrefaction were nowhere more noticeable than on the boundary line between the inhabited and uninhabited parts, where the refuse from an extremely populated country is floated down and mixes with the brackish water below, which, flowing backward and forward, is already saturated with putrefied matter.

The entire stretch of country known as Lower Bengal is only slightly raised above the sea level, and during the rainy season almost the whole extent is submerged. For this reason the inhabitants are compelled to build their huts upon raised ground. This is effected by taking the earth near where the hut is built in order to raise the ground on which the house stands. The result of this displacement is to leave a large tank adjoining each hut, in which soiled water and putrefied matter from the household rapidly collect. Strange as it may seem, this very water is used for drinking and household purposes, and in return receives much of the refuse which is necessarily thrown out.

Remaining in this locality several months, Dr. Koch was able to detect whatever slight fluctuations occurred, and was struck by the marked correspondence between these fluctuations and the prevalence of the disease in other parts of Europe. All European epidemics have been accompanied by a corresponding increase in the south of Bengal. During his stay, he performed over three hundred autopsies upon cholera corpses, and before leaving was successful in isolating from the discharges a micro-organism, which he called the comma bacillus of Asiatic cholera. On returning to Berlin, he demonstrated the organism before the Imperial German Board of Health, and enlisted in his cause such men as Virchow, Gaffky, Grawitz, Pettinkoffer, Hueppe, and other notable workers in the new field. They immediately set about confirming his observations, and with some slight variations arrived at his conclusions.

In view of the danger threatening the whole world, and the German nation in particular, the government now took up the subject, and deeming Koch's experiments the most reliable, accorded to him the distinction of acquainting representative physicians from every city and town in Germany with the practical part of his theory. A large laboratory was fitted up, and delegations of ten physicians succeeded each other in a ten days' course, under his immediate supervision. This plan was followed until every town had sent at least one representative.

It is the arrangement and working of this laboratory system which the writer has been called upon to describe.

The entire second story of the board of health building is devoted to the laboratory purposes, and for convenience has been divided into two large working rooms, besides several smaller apartments for individual research. A single room, perhaps twelve feet square, with double walls, between which is kept flowing a constant stream of corrosive sublimate solution (1 to 1,000), is called the *cholera-zimmer*, and in it is placed the little jar of cholera dejecta, which is replenished from time to time from cholera-infected localities. This room is closely watched, and except at stated intervals no one is allowed admission. Another room is fitted up with the apparatus adapted to bacteriological study, such as steam and hot air sterilizers, and the various materials used in the preparation of the cultivating media. The laboratory is heated by steam, and an even temperature maintained day and night.

The course which the writer was privileged to take began on the 15th of December and closed on the evening of the 24th. The daily session lasted from six in the morning until dusk. On entering, we were assigned to private rooms, and each given a suit of stiffly starched linen clothes, which we continued to wear during the working sessions of the entire course. Leaving all else behind, we proceeded to the so-called cooking room, where we found the various ingredients

necessary for the preparation of the cultivating media already weighed out for us. These we combined and sterilized, according to a set of rules peculiar to Koch's system, and with which I presume most of my readers are now more or less conversant. It requires the better part of two days to make the nourishing substances, but these rather dry details over, the work is more interesting.

On the morning of the third day we made our first visit to the *cholera-zimmer*. In the center of the room, on a plate of glass, stood the little tin box, about the size of a small pill box, containing the cholera discharges from which we were to make the inoculations. The glass plate was covered with filter paper, and saturated with sublimate solution. After inoculating the tubes of food gelatine, they were poured out in the liquid state upon sterilized glass plates, to allow the different species to colonize. By this means we were able to obtain a pure culture in about thirty-six hours. To impress the peculiar growth of this organism more strongly upon the mind, various other bacteria were cultivated at the same time, and the contrast between them made apparent by their manner of growth, rather than by their untrustworthy microscopic appearances.

In recalling the pleasant hours spent in this laboratory, it would be a gross oversight not to mention the midday lunch to which we were treated. From the time of entering in the morning until four or five o'clock in the afternoon, we were not allowed to leave the building. This, of course, necessitated some refreshment at midday, and in the good old German style it consisted of sandwiches and beer. The hours from ten to twelve each day were spent in the cholera room, and after passing through a thorough disinfection by means of extreme heat and cold, and a final washing in corrosive sublimate solution, we gathered about a long table, with Dr. Koch seated at the head. The conversation would naturally have to do with the morning's work, and to the writer the half hours thus spent proved by far the most interesting part of the course, taken up as they were with personal experiences, intermingled with rare bits of information pertaining to bacteriological study. The lunch over, the afternoons were given up to an examination of the cultures in their various stages of development, and the preparation of permanent microscopic slides.

The last three days were devoted to inoculation experiments upon rabbits, guinea pigs, and white mice. As to the results of these experiments, I may say that they were successful only when the culture was introduced directly into the deodenum. When fed to the animals in appreciable quantities, no trustworthy symptoms were induced, and at the autopsy it was invariably found that the microbes had perished during their passage through the stomach. This bears out Koch's theory of the fatal action of the gastric juices upon this organism. It also closely follows our knowledge of the disease, for some impairment of the digestive process has always seemed the most important factor in cholera infection.

In personal appearance Dr. Koch is slightly above medium height, of rather stout habit, with dark complexion and prominent features. His eyes are deep set, the result, no doubt, of prolonged study over the microscope. This condition, of course, gives additional prominence to the cheek bones. His manner is one of retirement, and not at all calculated at first to inspire a feeling of ease on the part of those with whom he comes in contact. Later, however, this feeling gives place to a gradual and ever-increasing attachment. He is a man whose convictions are well defined and adhered to with almost obstinate tenacity. He possesses the two qualities essential to a successful mycologist—patience and perseverance. Combined with these is a rare trait, the ability to define one's position clearly, to which no doubt a large share of his present success is due.—*Independent Practitioner.*

DR. ZUR NIEDEN'S PORTABLE HOSPITAL OR BARRACKS.

DURING the Franco-German war much difficulty was experienced in finding sufficient shelter for the wounded, although the principal battles occurred in the summer, when inexpensive and hastily erected sheds could be used for the patients, and in spite of the fact that the seat of war was in a cultivated country where there were many good dwellings, which could be used as hospitals, and railroads for the transportation of the wounded. This was not the case in the Russo-Turkish war, which extended into the winter and during which many battles were fought in an uncultivated region, where most of the dwellings were mud huts, and there was nothing but the long lines of wagons drawn by oxen for the removal of the wounded. The impressions caused by this condition of things prompted Wereschagin to paint horrible pictures of the suffering endured. Michaelis, the chief surgeon of the Austrian staff, who made a careful study of the war of 1877-78, tells us that the original invading army of 120,000 men was completely exterminated by typhus fever; and this he lays to the fact that a great number of sick men were placed among the wounded—because of the want of proper accommodations for the troops—and to the lack of cleanliness which marked the track of the Russian army.

The experiences of the German and French war, Wereschagin's pictures, and the accounts of Michaelis all urge us on to the discovery of some means of relief, which must be found in the erection of shelters on the track of the army and at their quarters. These shelters, while they contain proper arrangements for the comfort of the patients, must be made of materials which will not facilitate the spread of disease germs, as did the mud of the huts used by the Russian army. Buildings of this kind can either be made on the spot, of such materials as are at hand, or they can be made at home and forwarded to the army. Progress toward the perfection of barracks of the latter sort has been materially aided by the Empress of Germany, who always takes great interest in the work of the Society of the Red Cross, and who offered a liberal reward for the best competitive designs displayed at the Antwerp Exposition.

The arrangements of most of the portable barracks, models or full sized specimens of which were exhibited at Antwerp, were similar to those of permanent hospitals, except that they were more compact. For instance, in permanent hospitals from 37 to 40 cubic meters of air space are allowed to each bed, while the circular giving the conditions of the competition required only twelve cubic meters of air space to a bed. Such a concession of space might have many injurious results, as the air might easily become impure from infectious germs of exhalations, etc. This evil cannot be overcome by an increase of air space, for then the portable barracks would be so large as to be too heavy for transportation.

Other means must be found, and Dr. Zur Nieden has attempted to remove the difficulties by the arrangements shown in the accompanying cuts. He considers the closed building shown in Fig. 1 suitable for use in winter only, as then the air is not so easily polluted. When the weather grows warmer he changes his house into a tent by the removal of the side walls, as shown in Fig. 2; in summer the tent can be arranged for an open shelter by raising the sides, as illustrated in Fig. 3.

The walls and roof of the barrack shown in Fig. 1 are made in sections composed of frames covered on the inside with canvas and on the outside with roofing paper. Between the two covers there is a layer of air which helps to keep out the cold. The sections of the gable are secured to an iron frame, while those of the side walls are held to the iron frame only by buttons or similar fastenings, so that they can be quickly removed when only tent walls are needed. The floor is double, and that also is supported by an iron frame.

The ventilation of the room, which is of the greatest importance for the prevention of infection, is accomplished as follows:

1st. In winter (Fig. 1) the air is led out of the room by jacketed pipes.

2d. When it is cool, the boards forming the tops of the ventilators on the roof are opened by means of cords, the side away from the wind being raised, and then the wind acts to exhaust the air from the sick room.

3d. The exhaust becomes stronger if, as shown in Fig. 2, both boards are opened.

4th. In summer the sections of one side wall are taken out and placed on a stand, leaving only a canvas wall.

5th. When the weather becomes still warmer, the sections of both side walls are removed.

6th. On extremely warm days one or both sides of the tent can be raised. If only one side is raised and the other sprinkled, the evaporation will cool the air perceptibly.

7th. The disinfection of the floor, which is considered the chief seat of contagion, can be effected by raising the tent walls a short distance from the floor, so that a current of air will pass from one side to the other over the floor without striking directly on the patients in the beds. With care the floor can be disinfected in this way even in winter.

Two of the sections of each side wall are covered on the inside with boards instead of canvas, and when the frames are packed for transportation, these two sections form the top and bottom of the package, thus protecting the other frames and doing away with all need of boxes. The sections of the roof and other walls are protected in the same way. The parts are of such sizes that they can be packed on an open railroad car without difficulty, and if shipped on wagons three two-horse teams will be required for a barrack with fifteen or sixteen beds.—*Illustrirte Zeitung.*

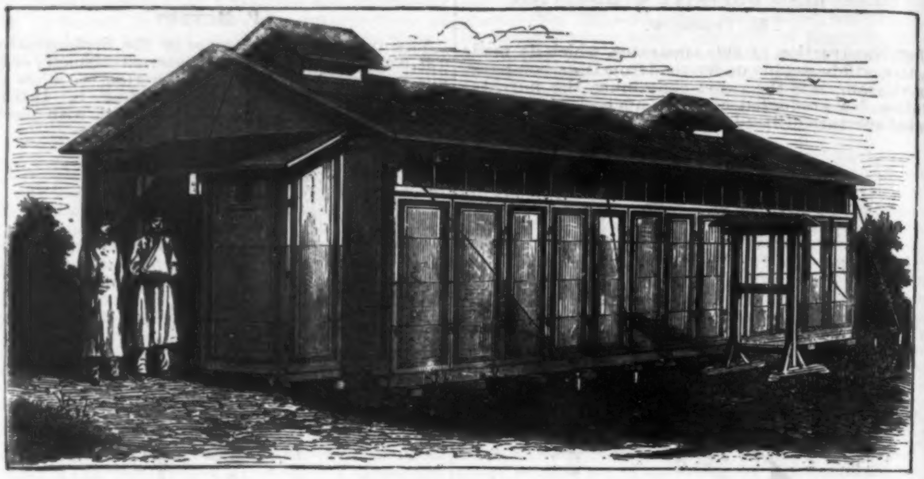


FIG. 1.

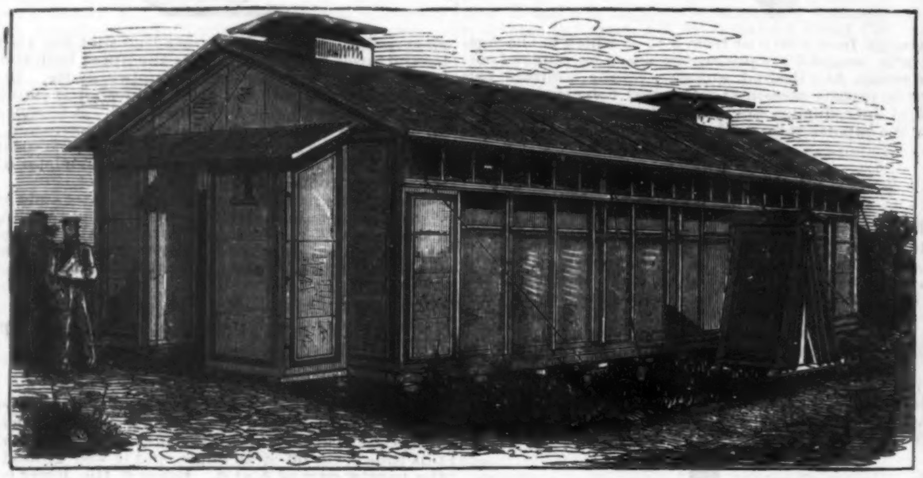


FIG. 2.

FIG. 3.

DR. ZUR NIEDEN'S PORTABLE HOSPITAL OR BARRACKS.

ON THE EXISTENCE OF CERTAIN ELEMENTS, TOGETHER WITH THE DISCOVERY OF PLATINUM, IN THE SUN.*

CONTRIBUTIONS FROM THE PHYSICAL LABORATORY OF HARVARD UNIVERSITY.

By C. C. HUTCHINS and E. L. HOLDEN.

LATE in the fall of 1886 it was decided by the writers, who were then at work in the physical laboratory of Harvard University, to attempt a revision of some of the previous work in regard to the chemical constitution of the sun, as well as to discover, if possible, new facts bearing on the same subject. For the purpose of this investigation a magnificent diffraction grating, made by Professor Rowland, of Baltimore, was kindly placed at our disposal by Professor John Trowbridge, under whose supervision and directions the subsequent work has been done.

After some delay, caused by the mounting of the grating and its attachments, work was begun early in January, 1887, but, owing to bad weather and other hinderances, was not regularly and systematically prosecuted till somewhat later.

The grating used is of speculum metal, with a ruled surface measuring 6 inches by 2, having 14,438 lines to the inch. It is concave, its radius of curvature being 21¼ feet, and is mounted according to Professor Rowland's method. Suffice it to say that the method is such that by simply rolling the camera along an iron track it passes not only from one part of the spectrum to another, but also to the spectra of different orders, at the will of the operator. As the distances on this track are proportional to the relative wave lengths of the lines that fall successively on a given point in the camera, it is easy, by means of a suitable scale of equal parts, placed beside the track, to set the center of the photographic plate instantly within a single wave length of any given line in the spectrum.

And here let us parenthetically state that all our wave lengths are those given by Professor Rowland's photographic map of the solar spectrum, the position of every line referred to being carefully identified upon the map, and its absolute wave length thus determined. Although some of the negatives contain many lines too faint to show on the map, yet we feel confident that our numbers correspond in all cases to those of the map within one-tenth of a wave length.

The light is brought into the room by means of a *porte lumière* and then sent through the slit after total reflection by a right-angled prism. Before striking the prism it passes through a cylindrical lens, which condenses it to a band of light about two inches long and one-eighth inch wide. The jaws of the slit move equally in opposite directions, so that, however widely they may be opened, no lateral displacement of lines can result from this cause.

Directly in front of the slit is placed a large tin lantern containing an electric lamp. The image of the arc can be brought exactly upon the slit by means of an adjustable lens in the front of the lantern. In the lower carbon of the lamp is made a cup-shaped cavity, which is filled with the substance a spectrum of which is desired. It is not at all necessary that this be in the form of a metal, for any ordinary compound is at once reduced by the intense heat and the presence of carbon vapor to the metallic state.

The plan of working has been as follows: The apparatus being arranged as described, the sunlight is admitted and the desired portion of solar spectrum photographed upon the upper half of the plate; then the sunlight is excluded by a shutter, and the image of the electric arc containing the proper metal is allowed to fall upon the slit, and its spectrum photographed on the lower half of the plate. (Most of the plates used were those made by the M. A. Seed Co., and were cut to the size of eight inches by two. The most sensitive plates were obtained, and even then we found the required time of exposure for some parts of the spectrum inconveniently long.)

In order to effect the exposure of either half of the plate at will, we placed directly in front of the camera an opaque screen, in which was a rectangular opening one half the size of the plate. By turning a handle, this screen is raised or lowered without the slightest disturbance of camera or plate. The metallic spectrum, being thus photographed immediately below the solar spectrum, can be compared with it at leisure.

These spectra are then examined with the aid of a glass magnifying about ten diameters, and any coincidences between solar and metallic lines carefully noted according to their wave lengths. In order to eliminate any personal error, they are examined by both observers separately, and their results afterward compared.

To eliminate errors arising from suspected impurities of materials, as also from the impurities known to exist in the carbons employed, we took what we called "comparison photographs." For these we placed in the carbon cup a portion of the substances known or suspected to be present as impurities in our metal, and then photographed the spectrum thus given on the upper half of the plate. A piece of the metal under experiment was then placed in the lamp, and the spectrum photographed on the lower part of the plate. Any lines due to impurities would then extend entirely across the plate, while those of the pure metal would extend only half way. In addition to this precaution we consulted all accessible tables and plates as to the position of known lines of metallic spectra, and also compared together all our photographs of the same region. If all of these tests left any doubt as to the origin of a given line, it was at once subjected to special investigation until all doubt was removed.

The dispersion given by the apparatus in the order of spectrum in which we worked is such that a single wave length occupies on the negative a space of 1·12 mm. This makes the distance between the lines D_1 and D_2 6·7 mm., while the length of spectrum from A to H is about 4·1 m. With so great dispersion it would hardly be possible to mistake the position of a line by any very considerable amount, or to confound neighboring lines belonging to different metals.

For reasons readily apparent, it was found so difficult to photograph under high dispersive power those parts of the spectrum not lying between wave length 3600 and wave length 5000, that our photographic work was done chiefly within those limits. It was, however, supplemented in many cases by eye observations in other portions of the spectrum.

We are convinced that there is much in the whole matter of coincidences of metallic and solar lines that needs re-examination; that something more than the mere coincidence of two or three lines out of many is necessary to establish even the probability of the presence of a metal in the sun. With the best instruments the violet portion of the solar spectrum is found to be so thickly set with fine lines that, if a metallic line were projected upon it at random, in many places the chances for a coincidence would be even, and coincidences could not fail to occur in case of such metals as cerium and vanadium, which give hundreds of lines in the arc.

Moreover, a high dispersion shows that very few lines of metals are simple and short, but, on the contrary, winged and nebulous, and complicated by a great variety of reversal phenomena. A "line" is sometimes half an inch wide on the photographic plate, or it may be split into ten by reversals.

At first we believed that these reversals were due to defects in the ruling of the grating, but we are convinced that they are true phenomena from the following experiments:

1st. The wings continue when various portions of the grating are covered.

2d. They are the same in three successive orders of spectra.

3d. They are very different in different metals, and in some are not seen at all.

4th. We arranged a flat grating, with collimator and projecting lens, each of five feet focus, and found that with this apparatus the same phenomena appeared.

On pages 87 and 88 of "The Sun," Professor Young gives a list of elements in the sun according to the best authorities, which is followed by a list of doubtful elements. Some of these we have examined, with the following results:

Cadmium.—The coincidence of the two lines given by Lockyer at wave lengths 4677 and 4799 is perfect. These are the only cadmium lines near, and the sun lines in the vicinity are not numerous.

Lead.—The evidence for lead, due to Lockyer, is based upon three lines at 4019·7, 4058·2, and 4061·8. We have photographed these lines with the sun many times. They are broad and nebulous, and often several times reversed. Lines in solar spectrum numerous and faint. 4019·7 and 4058·2 certainly do not coincide. 4061·8 is very difficult to pronounce upon; it may coincide.

Cerium, Molybdenum, Uranium, and Vanadium.—These four metals may be classed together. Lockyer finds four coincidences each for molybdenum and vanadium, three for uranium, and two for cerium. The arc spectrum of each is characterized by great complexity and vast numbers of lines. So numerous are the lines, in fact, that often on the photographs the total space occupied by them is greater than the space not so occupied. A plate ten inches long may contain a thousand or so. Evidently coincidences between these and solar lines cannot fail to occur as matters of chance, and therefore prove nothing. One can easily count a hundred or so such coincidences without the slightest conviction that the connection is other than fortuitous. Of course all this is nothing against the probability of these metals being in the sun; but at the same time those peculiarities of grouping, strength of lines, and other characteristics which occur in the case of iron and other spectra, and which alone can serve as evidence in such cases, are conspicuously absent.

Among the metals whose existence in the solar atmosphere has seemed probable, we have examined the following:

Bismuth.—The line of the above metal at 4722·9, the only line of bismuth in the arc in that whole region, coincides perfectly with the more refrangible of a very faint pair of solar lines.

Tin.—The solitary tin line at 4525, thought by Lockyer to coincide, falls directly between two fine lines in the solar spectrum.

Silver.—Lockyer mentions a certain possibility of silver in the solar atmosphere from the apparent agreement of two of its nebulous lines with solar lines. One of these we have never been able to find in the course of many photographs of the region in which it is given by him.

We find seven lines of silver between 4000 and 4900. Of these seven, three are what Thalen calls nebulous; so broad and hazy that their true positions cannot be determined with much accuracy. These lie at about 4055·5, 4063·6, and 4212. A fourth line at 4023 is of the same general character, but has a sharp reversal which agrees with a solar line. The remaining three lines are represented in the sun, and are given by Thalen in the spark spectrum of the metal.

4476·2. Very strong line; nebulous on lower edge. Sun line strong. (Thalen, 4475.)

4668·8. Strong, solitary line. (Thalen, 4666·5.)

4874·3. Fairly strong. (Thalen, 4874.)

Thus, between the limits given above, every line of silver, as far as can be determined, coincides with a solar line.

Potassium.—We could find but two lines of potassium, the same that were examined by Lockyer, 4044·5 and 4048·35. Each line is reversed four times, which increases the difficulty of locating them exactly. 4048·35 seems to agree with a solar line. The solar line near 4044·5 is very faint, and it is next to impossible to decide the question of an agreement.

Lithium.—The blue line of lithium presents a curious case. The very broad and nebulous line has a rather sharp reversal near the center, and somewhat toward the lower edge a broader and less clearly defined reversal. Both these reversals agree with solar lines at 4602·5 and 4603·2. It is possible that one of the reversals may be due to the presence of some other substance, say calcium. But if that were true, it would seem that both reversals would be nearly, if not quite, obliterated. Further experiment may clear the matter up. 4603·2 is given to iron by Thalen.

Platinum.—As far as we can learn, no evidence has hitherto been offered to show the occurrence of this metal in the solar atmosphere. We were somewhat surprised, therefore, upon meeting with coincidences. Between 4250 and 4950 we find 64 lines of platinum, sixteen of which agree with solar lines. The latter are at the following places:

4291·10	4481·85
4392·00 (Thalen 4389·4)	4552·80 (Thalen 4551·8)
4430·40	4560·30
4435·20	4580·80
4440·70	4852·90 (Thalen 4851·5)
4445·75 (Thalen 4442·0)	4857·70
4448·05	4899·00
4455·00	4932·40

We have taken all possible care to make this statement accurate, and to admit no lines about which there seems to be any question. There are seven other lines not included in the list, the probability of agreement of which is at least as good as that upon which potassium is admitted.

In all these experiments everything has been done to bring out and show upon the photograph as much as possible. The lamp, constructed for the purpose and fed by a powerful dynamo, gave an arc from a half to three-fourths of an inch long, and with a long flame and so intense a heat that it could be worked for but a few minutes at a time. Any one who has carried out a series of experiments like this is alone competent to appreciate the great labor and the endless difficulties and perplexities that attend them.

Our thanks are especially due to Dr. Wolcott Gibbs for his hearty encouragement, and for the use of valuable apparatus and chemicals.—*Amer. Jour. Science.*

* From the Proceedings of the American Academy of Arts and Sciences, vol. xxiii.

ANIMALS DESTRUCTIVE TO SUBMARINE CABLES.

IT was in the seas of the Levant that the ravages made in the wrappings of cables by submarine animals were first discovered. In 1859, Mr. Siemens found millions of small animals, some provided with shells, and others like worms, upon a hemp-wound cable that had been laid scarcely a year. The hemp had disappeared, and round holes were bored here and there in the gutta percha. Since then, injuries have been detected in numerous cables in almost all seas, and notably in the western basin of the Mediterranean, the English Channel, the Irish Sea, and the Atlantic Ocean; and particularly off the coasts of Brazil, the Persian Gulf, the Indian Archipelago, etc. These were due to various species of animals, the chief of which are known to naturalists by the names of *Teredo navalis*, *Xylophaga*, and *Limnoria lignorum*.

The *Teredo navalis* (Fig. 1) is a sort of worm of gray-

FIG. 1.—TEREDO NAVALIS.

ish color, belonging to the family of acephalous mollusks, and sometimes reaching a length of twelve inches. It has a globular swelling at one of its extremities, which protects two little shells, and at its opposite extremity two conduits that it is capable of extending or contracting at will, and that serve for taking in and expelling the materials necessary for its nutrition. To these two conduits are attached two slightly convex organs, which in uniting form a protection for them. After the teredo has reached an adult age it retires into the galleries that it has excavated and covers itself with calcareous matter. It is reproduced by means of eggs, which, after remaining some time in the branchiæ of the female, are deposited in the sea.

The teredo attacks the hardest wood that it meets in the water. Large oak piles in the docks at Plymouth have been entirely destroyed by these animals within the space of four years. The ravages that it commits in the hulls of wooden ships have been arrested by copper sheathing, and it appears that better results yet have been obtained by covering the surface of the wood to be protected with broad-headed iron nails. Mr. Quatrefages advises that small quantities of some salt of mercury, lead, or copper be occasionally thrown into waters infested with the teredo, so as to distroy the eggs floating in them.

The *Xylophaga* is a bivalve allied to the teredo, from which, among other peculiarities, it is distinguished by not lining the galleries that it excavates with calcareous secretions. Like the teredo, it destroys by preference the hempen winding of cables, and seems to make its way along the gutta percha, the surface of which it occasionally cuts without penetrating the substance to any depth.

The opinion has even been put forth that animals of the genus *Teredo* are attracted to cables only by the tar and hemp, and attack the gutta percha in order to taste it. The following fact seems to give some probability to this opinion. At the time of the repairing of the cable from Dover to Calais, in 1851, it was found

that the hemp had entirely disappeared at every point where the corrosion of the iron had exposed it, but the gutta percha contained but two apertures that extended as far as to the copper wire. On another hand, every portion of the experimental Dover-Calais cable of 1850 that has been taken out of the sea up to the present has been found free from the attack of any animal whatever. It will be remembered that this cable comprised but one copper wire covered with gutta percha without any external protection.

The *Limnoria lignorum* or *tenebrans* (Fig. 2), the most formidable enemy of gutta percha, is a small crustacean of the size of an ant, which easily slips through the narrowest interstices between the wire covering of a cable, in order to reach the inside, which it perforates here and there as far as to the copper conductor. Its head is armed with five or six pairs of hooks. Appendages similar to those of the lobster are attached to the six first segments of its body, and the last segment is provided with a pair.

Animals that perforate cables do not, as a general thing, inhabit great depths. Yet, in 1880, in the oldest cable from Marseilles to Algiers, at a depth of more than 900 fathoms, we found damages that were imputable to them. The gutta percha exhibited the gnawings of a worm for a length of more than five hundred feet, but it contained but one aperture that extended as far as to the copper conductor. The hemp at all of these points was intact, the external iron was in no wise deteriorated, and the external bituminous covering still adhered to the iron, but was readily detachable.

On land, the gutta percha is exposed to the attacks of other animals still, among which may be mentioned rats and the *Templetonia crystallina*, a microscopic insect of the family Podure, found in England on subterranean telegraph lines.

Submarine cables are sometimes destroyed, too, by animals of large size that people the sea, such as whales, sharks, and sword fishes.

On various cables, especially those of Florida and the seas of China, traces of sharks' bites have been found, and teeth belonging to the hammer headed shark, which frequents the southern portions of the Mediterranean, have been found upon a denuded part of the old cable from Malta to Alexandria, and also between the wires of the covering of the French cable that twenty years ago connected Sicily with Bizerte.

The cable from Para to Demerara has, at several times and in several places, been attacked by sword fishes, which abound off the coast of Brazil, whither

FIG. 2.

they are attracted by whales. These fish are in the habit of digging into the sea bottom with their buccal appendage in order to find food therein. It is probable that their "sword" sometimes enters the interstices between the wires of the cable covering, and in their efforts to disengage it they injure the internal portions. In 1881, Sir Henry C. Mance raised from the Persian gulf a length of cable in which a sword fish's tooth was implanted, traversing the gutta percha and reaching the copper conductor.

In 1876, during the repairing of the Kurrachee-Gwadur section of this same cable, an unexpected resistance was experienced in the vicinity of the break, as if the cable were fastened to a rock. After some perseverance, an enormous whale was hauled up entangled in the cable. The cetacean's body was caught just above the tail and bound by two and a half revolutions of the cable. The tail, which was twelve feet wide, was in a perfect state of preservation, and was covered with numerous shellfish. Sharks and other fishes had partially devoured the carcass, which was already nearly decomposed, and to such a point that the jaws separated from it on reaching the surface. Probably the whale had used the cable hanging over a submarine precipice as a scraper to free itself from the parasites that infest all cetaceans, and had with a single blow of its tail broken the cable and wound it several times around its body in such a way as to be strangled by it. The soundings made at this point showed a depth of from 30 to 70 fathoms.—*From La Lumière Electrique.*

THE CHURCH OF THE HOLY SEPULCHER, JERUSALEM.

A LETTER has been written to Mr. Glaisher, the president of the Palestine Exploration Fund, by Sir Charles Wilson, giving an account of the late discoveries in Jerusalem by Mr. Schick:

"At the southeast corner of the block of buildings which includes the church of the Holy Sepulcher, the Russian and Greek churches have been clearing the ground and erecting new buildings. The result of these improvements has been to sweep away the old street mentioned in 'La Citez de Jherusalem' (about 1187 A.D.) as 'une rue coverte a voute, par u on va el mostier del sepulcre.' In this street the Syrians sold cloth, and made the wax candles which were in so much request in the neighboring church. Many years ago—so many that all remembrance of the fact had been lost—the street was walled up, and no one suspected that it had remained almost intact to our own day until Mr. Schick's communication was received. The letter is fortunately accompanied by a good plan, which is the only authentic record we have of the position and arrangement of one of the most frequented bazars of the Jerusalem of Godfrey and Baldwin. The removal of the old street, or bazar, led to a discovery of even greater interest, viz., that it had been built upon an ancient pavement of very large flat stones, of great thickness, which proved to be a continuation of the pavement found some years ago in the ground to the north owned by the Russians. This pavement is probably the work of Constantine, part of the 'space open to the sky which he paved with polished stones,' or of the wide market place at the east end of his group of churches in honor of the place of our Lord's resurrection."

Mr. Glaisher considers that if this pavement be accepted as Constantine's—of which there is little doubt—there is an end of a very important part of the controversy which has raged for so many years over the so-called church of the Holy Sepulcher, and the theory of the late Mr. James Fergusson is finally disposed of. Constantine's site is thus proved to have been that in which the present church stands. This gives the Sepulcher an uninterrupted existence as a place of veneration for 1550 years.

DISCOVERIES IN ROME.

THE church of SS. Giovanni e Paolo, on the Cœlian hill, in Rome, stands on the site of the house where the two brothers to whom the church is dedicated were martyred by Julian the Apostate. The present building was erected in the beginning of the eighteenth century, from the design of Antonio Canavari, at the cost of the Cardinal Paolucci. The eight Ionic columns supporting the portico are supposed to have belonged to some classic building. The church is well proportioned, and has a fine pavement. There has always existed a belief that the ground was formerly occupied by some important buildings. There are remains in the convent garden which, according to one party of archæologists, belonged to a second curia that was erected by Tullus Hostilius; there are other men who say the arches formed part of a palace erected by Tullus after he had sent the people of Alba to dwell on the hill; while, according to a third theory, the arches were part of the *vivarium* where the wild beasts were kept before they were driven into the amphitheater.

The traditions, as well as the remnants of antiquity, are enough to incite the Passionist Fathers to undertake researches, and the recent operations have been most successful. Some time since, owing to the exertions of the Passionist monk Father Germanus, two chambers of a Roman house of the fourth century were discovered under the high altar of the church of SS. John and Paul, on the Cœlian hill. Quite lately another large chamber has been discovered beneath the nave of the church, which seems to have been the *tabularium* of the house.

The traces, very well preserved, are visible of what must have been valuable paintings, representing wild beasts, sea horses, and other decorations. Especially remarkable are two pictures of unquestionable Christian character. One represents the patriarch Moses in the act of removing his shoes before approaching the burning bush, a subject which is also represented in one of the pictures in the catacomb of Calixtus. The other represents a woman praying. She is clad in a tunic, with a veil on her head, a necklace of pearls, and arms outstretched. This is believed to be the first specimen of a Roman house in which scenes of a Christian character have been found represented. Such subjects have hitherto been found only in the catacombs.—*The Architect.*

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